REMEDIAL INVESTIGATION/ FEASIBILITY STUDY WORK PLAN

NASA - JET PROPULSION LABORATORY
4800 Oak Grove Drive
Pasadena, California 91109

prepared by

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3000 West MacArthur Boulevard
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January 1991

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN FOR THE
NASA-JET PROPULSION LABORATORY

Prepared For:

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1.0 INTRODUCTION

The Jet Propulsion Laboratory (JPL), located at 4800 Oak Grove Drive, Pasadena, California, is a NASA owned facility managed by the California Institute of Technology. In 1988, Ebasco Services Incorporated conducted a Preliminary Assessment/Site Inspection (PA/SI) (Ebasco 1988a, 1988b) and in 1990 conducted an Expanded Site Inspection (ESI) at JPL (Ebasco, 1990a). The data collected during the PA/SI and ESI will be used by the Environmental Protection Agency to provide a Hazard Ranking System (HRS) score for JPL. The HRS score is used to rank sites for potential listing on the National Priorities List. The results obtained to date indicate the presence of volatile organic compounds (VOCs) in groundwater beneath the site and nearby production wells. In anticipation of being placed on the National Priorities List, JPL requested this work plan for a Remedial Investigation/ Feasibility Study (RI/FS) of groundwater and potential source areas containing volatile organic compounds. If JPL is placed on the NPL, the facility will be subject to the provisions of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) as amended. This Work Plan was prepared using the Environmental Protection Agency document titled "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (EPA 1988a) and the RI/FS will meet all CERCLA requirements.

1.1 Purpose of Work Plan

The purpose of this Work Plan is to present the technical scope of work of the RI/FS and an estimated schedule for evaluating both groundwater and potential source areas at JPL. The Remedial Investigation (RI) will include site characterization: an evaluation of the lateral and vertical extent of on-site and off-site VOCs and an assessment of risks to public health and the environment. The FS will identify and evaluate the potential remedial alternatives to reduce these risks to acceptable levels.

The purpose of the RI is to evaluate potential VOC contaminant sources, the extent of VOC migration pathways, and the risk to actual and potential receptors. The RI will include the collection of field data, incorporation of existing data, and data analysis to define the nature and extent of VOC migration.

Following the completion of the RI, the data collected will be evaluated as part of an endangerment assessment (EA) of risk to potential receptors. The purpose of this effort will be to quantify risks posed by the VOCs in groundwater and source areas and set forth criteria which can be used to evaluate remedial alternatives, if necessary, as part of the Feasibility Study (FS).

The purpose of the FS is to utilize the RI site characterization and the endangerment assessment (EA) to identify potentially applicable remedial technologies to the media of concern and to formulate these technologies into a cost-effective remedial action or set of remedial actions. These technologies are intended to permanently prevent or minimize the release of hazardous substances that may cause environmental contamination and substantial risk to present or future public health. This objective will be accomplished through the identification, screening, testing, and evaluation of remedial alternatives based on cost-effective, technical, public health, environmental, and institutional concerns.

The flow of information between the RI, EA, and FS is essential to a streamlined, effective process. A phased approach to the RI will be implemented to collect information necessary to determine the feasibility of various remedial alternatives. Likewise, a phased approach to the FS will be dictated by the information collected during the RI (Figure 1-1).

1.2 Approach

The approach of this Work Plan is to conduct the RI/FS in phases in accordance with EPA's recent Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (October 1988). The various phases of the RI/FS are outlined on Figure 1-1. Activities which will be conducted during the RI/FS are also identified by task numbers. For federal-lead sites, standard tasks have been defined to provide consistent reporting and allow more effective monitoring of the RI/FS process. This RI/FS is being conducted by JPL and will be conducted using tasks similar to those conducted

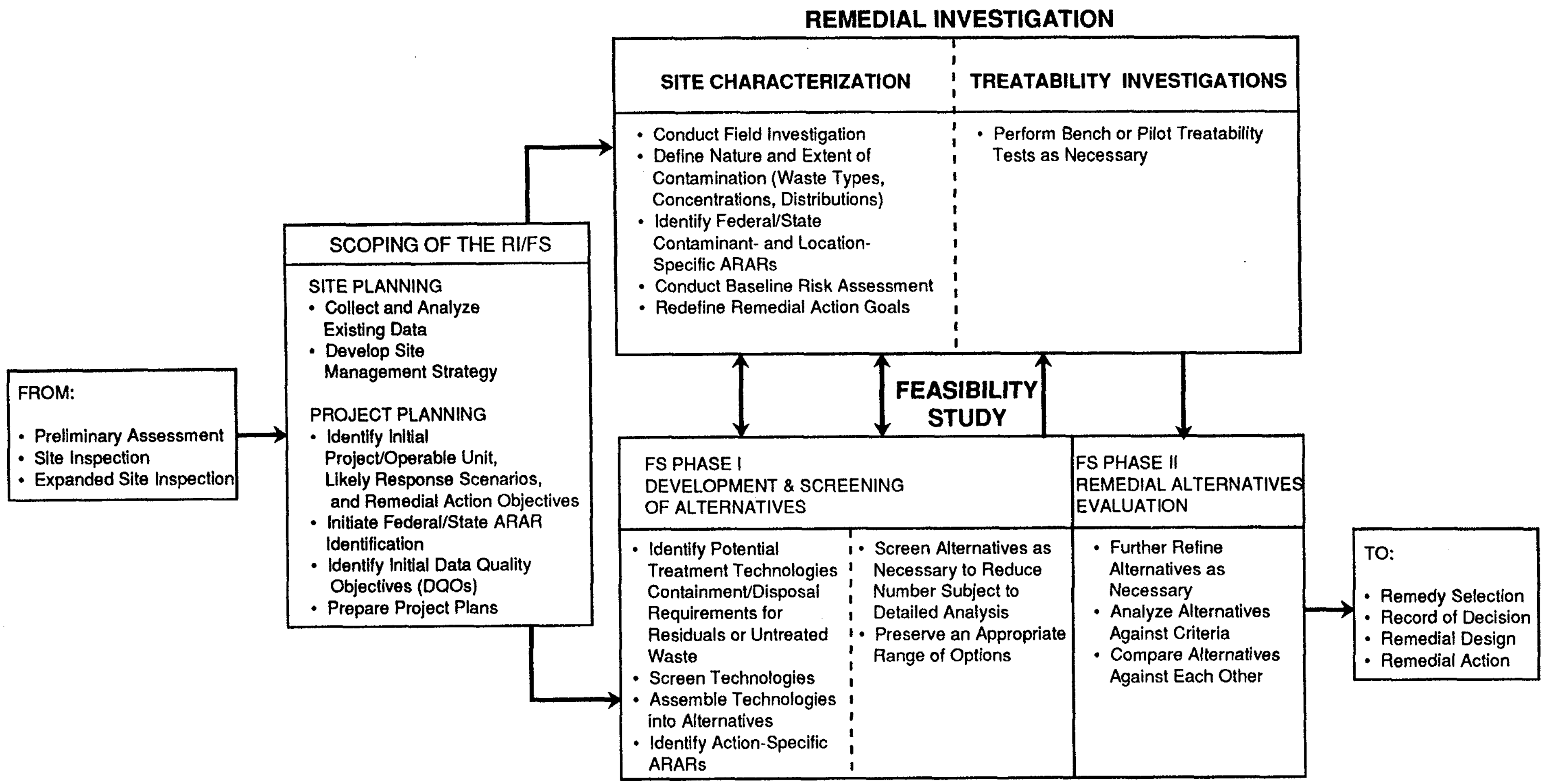


Figure 1-1

PHASED RI/FS PROCESS

SOURCE: *Modified from EPA (1988).*

by EPA. Figure 1-2 shows these tasks and their relationship to the phases of an RI/FS. A brief description of the tasks which will be part of the work to be conducted at JPL is given below. The RI and the FS will be conducted concurrently and data gathered in the RI will affect the development of remedial alternatives in the FS, which in turn influences additional field investigations. Because of the interactive and iterative nature of the RI/FS process, the sequence of the various phases and associated activities, as summarized on Figures 1-1, and 1-2, may be less distinct in practice. The time sequencing of individual activities will depend on specific site situations.

All phases and associated tasks described in this work plan were designed for the attempt to characterize onsite conditions and to address the feasibility of onsite remediation. When the onsite situation is more fully understood, JPL's possible contribution to offsite contamination can be addressed.

Task 1. Project Planning

The project planning task includes activities related to initiating the RI after the work plan is finalized and issued. This task is complete when the work plan and supplemental plans are approved and field work can begin. Typical activities included in this task are:

- Obtaining easements/permits/site access
- Collection and reevaluation of existing data
- Refinement of conceptual site model
- Finalizing of data needs and data quality objectives
- Refinement of preliminary remedial action objectives and potential remedial alternatives
- Development of treatability studies that may be necessary
- Preparation of specifications
- Subcontract procurement
- Coordination with analytical laboratories
- Task management and quality control

TASK APPROACH

RI / FS WORK PLAN
STANDARD TASKS

TASK TITLE

1 Project Planning

2 Community Relations *

3 Field Investigations

4 Sample Analysis/Validation

5 Data Evaluation

6 Risk Assessment

7 Treatability Study/Pilot Testing

8 Remedial Investigation Report

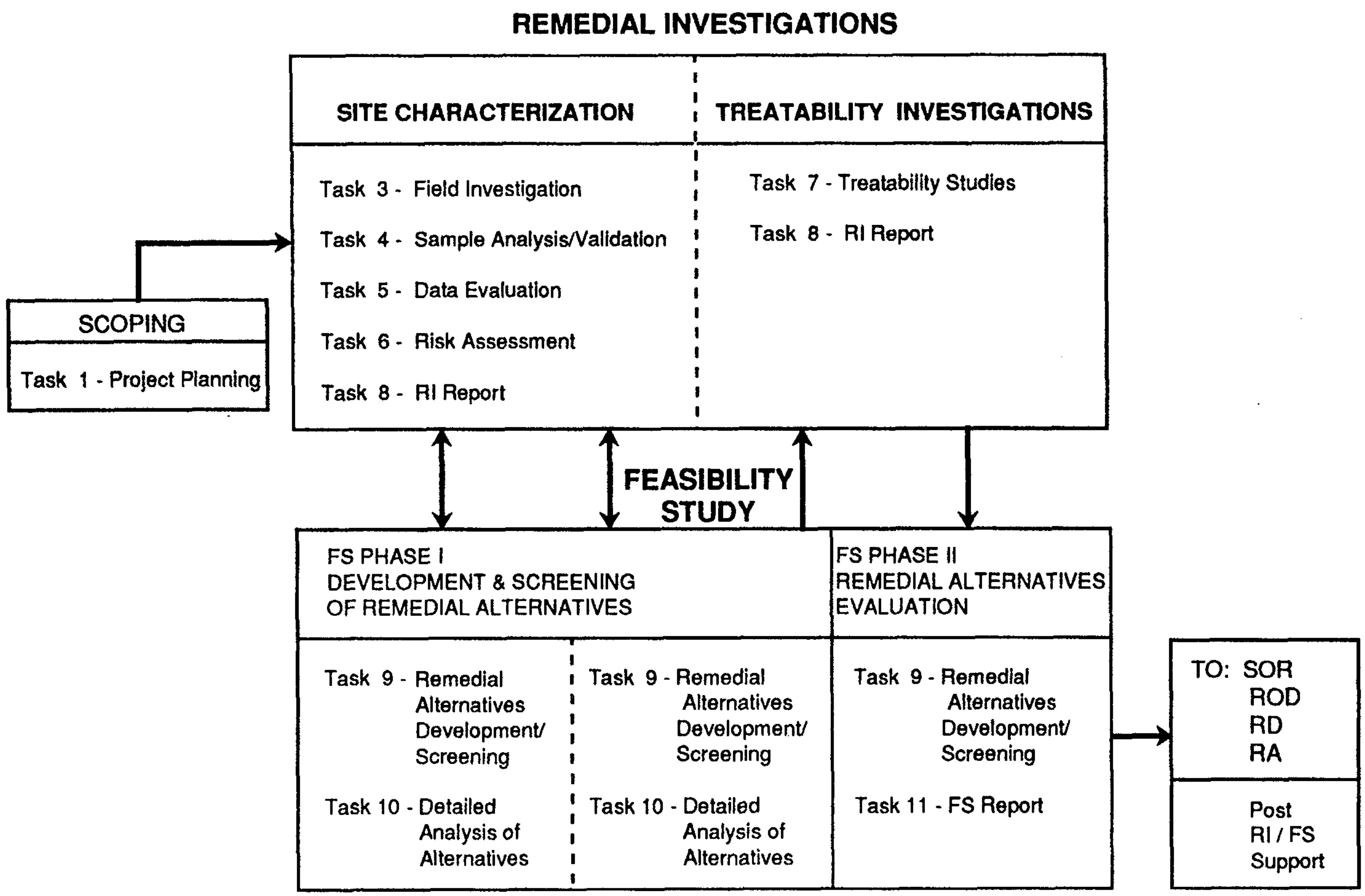
9 Remedial Alternatives Development/Screening

10 Detailed Analysis of Alternatives

11 Feasibility Study (FS) Report

* Tasks that can occur in any phase of the RI / FS

PHASED APPROACH



SOURCE: Modified from EPA (1988).

Figure 1-2

RELATIONSHIP OF PHASED RI/FS TO TASK ORIENTED RI/FS

Task 2. Community Relations

The Community Relations task incorporates all activities related to preparing and implementing the site community relations plan. Typical activities included in this task are:

- o Conducting community interviews
- o Preparing a community relations plan
- o Preparing fact sheets
- o Providing public meeting support
- o Providing technical support of community relations
- o Implementing community relations

Task 3. Field Investigation

The Field Investigation task consists of all activities related to conducting field work required by the RI, including subcontractor procurement. Field investigation is complete when all subcontractors are demobilized from the field. Typical activities included in this task are:

- o Mobilization
- o Geophysical investigations
- o Soil and ground water sampling
- o Geological/hydrogeological investigations
- o Well elevation and location survey
- o Field screening/analyses
- o RI waste disposal
- o Task management and quality control
- o Demobilization

Task 4. Sample Analysis/Validation

The Sample Analysis/Validation task includes tracking of samples after they leave the field and review of the analytical activities conducted for each sample. Separate monitoring of support laboratories may be required. This task begins the date the first set of samples in sent to the laboratory for analysis and ends when data validation is complete. Typical activities included in this task are:

- o Sample management
- o QA/QC evaluation
- o Data validation
- o Testing physical and chemical parameters onsite
- o Task management and quality control

Task 5. Data Evaluation

The Data Evaluation effort includes an analysis of physical and chemical analytical data after validation. Once the validated data are received, they can be evaluated prior to preparing the RI report. The following are typical activities:

- o Data evaluation
- o Data reduction and tabulation
- o Environmental fate and transport modeling/evaluation
- o Task management and quality control

Task 6. Risk Evaluation

The Risk Evaluation task includes activities needed to conduct and present an endangerment assessment (EA) which will assess the potential human health and environmental risks associated with the site. Initial work will begin during the RI and end upon completion of the EA report. Typical activities may include:

- o Identification of contaminants of concern
- o Exposure evaluation
- o Toxicity evaluation
- o Risk characterization
- o Task management and quality control

Task 7. Treatability Studies

The Treatability Studies task includes any efforts related to conducting bench-scale or pilot evaluations of potential remedial alternatives, and associated task management and quality control. CERCLA contains provisions which affect the level of effort associated with this task. Bench studies are often sufficient to evaluate performance of technology that is well developed and tested. For innovative technologies, a pilot test may be required. Typical activities may include:

- Test facility and equipment procurement
- Vendor procurement
- Equipment operation and testing
- Sample analysis and validation
- Report preparation
- Task management and quality control

Task 8. Remedial Investigation Report

The Remedial Investigation report will be generated during this task that describe the findings of the RI once the data has been evaluated under Tasks 5 and 6. This task ends when the last RI document is submitted to EPA. Typical activities may include:

- Data presentation
- Writing of the report
- Reviewing quality control (QC) efforts
- Printing and distributing report
- Review meetings
- Report revision based on review comments
- Task management and quality control

Once the RI and EA are completed a Feasibility Study may be required to evaluate potential remedial alternatives. Three activities are typically associated with completion of an FS including:

- o Remedial Alternatives Screening,
- o Remedial Alternative Evaluation, and
- o Feasibility Studies Report.

Task 9. Remedial Alternatives Development and Screening

The Remedial Alternatives Screening task includes a preliminary evaluation of remedial alternatives for the media of concern. This task starts when sufficient physical and chemical data is available to quantify volumes and cleanup criteria are set. The task is complete when a final set of alternatives is chosen for detailed evaluation. Typical activities may include:

- o Identification of potential alternatives
- o Evaluation of each alternative based on screening criteria
- o Review and provide QC of work effort
- o Report preparation
- o Refine list of alternatives to be evaluated

Task 10. Remedial Alternatives Evaluation

A detailed remedial alternatives evaluation task will begin when the screening done in Task 9 is complete and includes the detailed analysis and comparison of remedial alternatives. The activities comprised in this task included performing human health, environmental, and institutional analyses. The detailed analyses include the following activities:

- o Refinement of alternatives
- o Comparative analyses of alternatives against established criteria
- o Review of QC efforts
- o Task management and quality control

Task 11. Feasibility Study Reports

The Feasibility Study Report will describe the findings of the detailed Remedial Alternatives Evaluation, costing, and selection of preferred alternatives. Typical activities include:

- o Data presentation
- o Graphics associated with the report
- o Writing of the report
- o Costing details
- o Printing and distributing the report
- o Report revisions based on reviewers comments
- o Task management and quality control

1.3 WORK PLAN ORGANIZATION

This Work Plan includes a description of all the major elements which will be part of the RI/FS for JPL. Section 2.0 describes and evaluates existing data for the site, discusses the scoping for the RI/FS, contains a preliminary risk evaluation, reviews the applicable or relevant and appropriate requirements (ARARs) for remedial investigations and remediation, describes data quality objectives (DQO) for the RI/FS, identifies the need for additional data, and summarizes the community relations program proposed for JPL. Section 3.0 presents a description of the Remedial Investigation. Section 4.0 presents a description of the FS Phase I Feasibility Study: Development and Screening of Remedial Alternatives. Section 5.0 presents a description of Phase II Feasibility Study: Remedial Alternatives Evaluation and Selection. Section 6.0 presents Ebasco's project management approach and Section 7.0 presents the estimated project schedule.

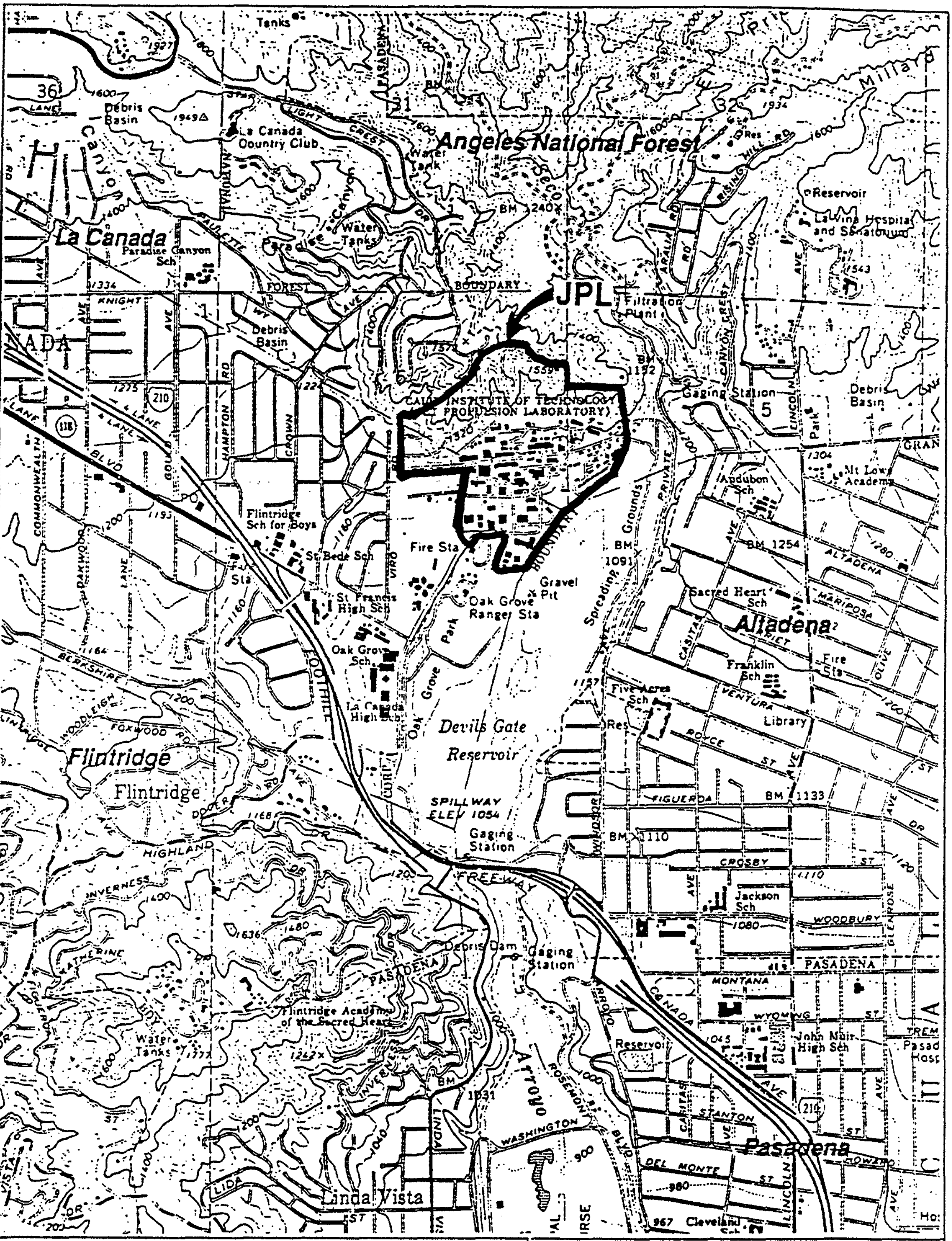
2.0 SITE DESCRIPTION

The Jet Propulsion Laboratory (JPL) is located within the cities of Pasadena and La Canada-Flintridge, California, northeast of the 210 Foothill Freeway. The site covers 176 acres, and is situated in an alluvial fan at the base of the southern edge of the San Gabriel Mountains. JPL is located immediately northwest of the Arroyo Seco intermittent stream bed, and north of the Devil's Gate Reservoir (Figure 2-1).

2.1 SITE BACKGROUND

CERCLA, as amended, stipulates that federal facilities such as JPL, where hazardous materials may have entered the environment, perform a Preliminary Assessment. Ebasco Services Incorporated conducted a Preliminary Assessment/Site Inspection (PA/SI) of JPL in 1988 (Ebasco, 1988a, 1988b). The data collected during this PA/SI was used by Ebasco to calculate a preliminary Hazard Ranking System (HRS) score for JPL. From January to March 1990, Ebasco conducted an Expanded Site Inspection (ESI) of JPL (Ebasco, 1990a) to provide additional supporting data and documentation for the Environmental Protection Agency (EPA) who will ultimately provide a HRS score for JPL. The HRS score is used by the EPA to rank sites for potential listing on the National Priorities List (NPL).

The Jet Propulsion Laboratory was first developed by the U.S Army between 1945 and 1957 and remained under the Army's control until it was taken over by NASA in 1958. The California Institute of Technology is currently under contract to NASA. JPL is responsible for research and development for aeronautics, space technology, and space transportation. JPL is currently involved in exploration of the earth and solar system with automated spacecraft, the design and operation of the global Deep Spacing Tracking Network, and other research and development activities. Since 1958, JPL has managed the Ranger and Surveyor missions to the moon; the Mariner missions that explored Mars, Venus, and Mercury; the Viking Mars Orbiters; the Voyager missions to Jupiter, Saturn, Uranus, and Neptune; and the earth-orbiting Infrared Astronomical Satellite (IRAS). The latest of JPL



Source: U.S. Geological Survey
Pasadena Ca. Quadrangle (1966)
Scale: 1:24,000

N
W E
S

FIGURE 2-1
SITE LOCATION MAP
Jet Propulsion Laboratories

missions to explore the planets in more detail include Galileo, a Jupiter orbiter and probe, and Magellan, a Venus orbiter.

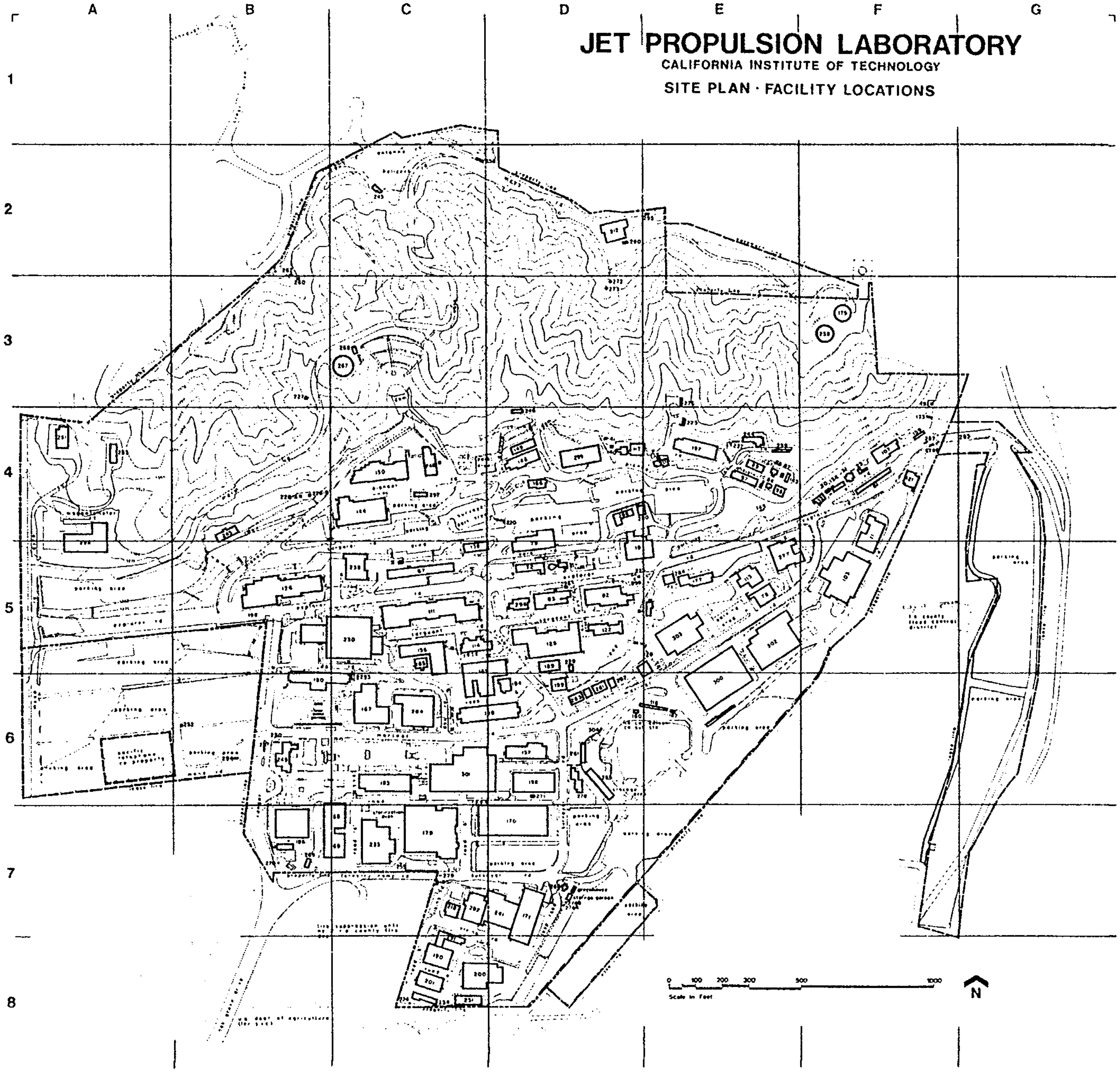
To accomplish these tasks, a variety of support functions and research and development laboratories using various chemicals are and have been present at JPL. The general types of materials used, now and in the past, include a variety of solvents, solid and liquid rocket propellants, cooling tower chemicals, sulfuric acid, freon, mercury, and various chemical lab wastes.

During the 1940's and 1950's, nearly every building at JPL maintained a cesspool to dispose of liquid and solid wastes through drains and sinks within that building. These cesspools were designed to allow liquid wastes to seep into the surrounding soil. Since nearly every building at JPL at one time either used or stored various quantities of hazardous chemicals, it is believed that the cesspools received various quantities of chemicals used at the facility. Although the cesspools have been abandoned since the late 1950's and early 1960's, a number of these cesspools may have been sources of VOCs. Figure 2-2 shows the locations of buildings and the road system currently at JPL.

2.1.1 Hydrology

JPL is located in the Monk Hill Basin which is located within the Raymond Basin (see Figure 2-3). The Raymond Basin is a small triangular groundwater basin bounded on the north by the San Gabriel Mountains, on the west by the San Rafael Hills and on the south by the Raymond Fault. The Raymond Basin provides an important source of potable groundwater for many communities in the area including Pasadena, La Canada-Flintridge, San Marino, Sierra Madre, Altadena, Alhambra, and Arcadia. The aquifer under JPL is not designated as the sole or principal drinking water source for JPL.

The Raymond Basin's climate is semi-arid Mediterranean, characterized by hot, dry summers and mild winters with intermittent rain. The long-term average annual precipitation in the area is 22.5 inches. Approximately three-fourths of the annual precipitation occurs during the months of December through March. Groundwater levels fluctuate during the year with



Facility Locations

No.	Facility Title	Location
11	Space Sciences Laboratory	4-F
18	Structural Test Laboratory	5-D
20	Thermionic Converter Laboratory	4-F
23	Vacuum Furnace Laboratory	4-F
31	Metallographic Laboratory	4-F
32	Thermionic Converter Laboratory	4-F
67	Material Research	5-C
72	Engineering Offices	5-D
78	Hydraulics Laboratory	5-E
79	Wind Tunnel (20 Inch)	4-D
81	Space Sciences Laboratory	4-F
82	High Vacuum Laboratory	5-D
83	Quality Assurance	5-D
84	Chemical Materials Laboratory	5-E
86	Solid Oxidizer Laboratory	4-E
87	Propellant Conditioning Laboratory	4-E
88	Wiring Laboratory	4-E
89	Laser Laboratory	4-E
90	Pyrotechnics Laboratory	4-E
91	Air Dryer	5-D
97	Development Laboratory and Offices	4-E
98	Solid Fuel Laboratory	4-E
103	Fabrication Shop	5-F
107	Laser Research Laboratory	4-F
111	Technical Information	5-C
113	Pneumatics Laboratory	5-E
114	Electronics Development	5-C
116	Propellant Storage Dock	6-E
117	Liquid and Solid Propellant Laboratory	4-D
121	Analytical Instruments Laboratory	4-F
122	Energy Conservation Systems	5-D
125	Combined Engineering Support	5-D
126	Information Systems Development	5-B
129	Combustion Research Laboratory	5-E
134	Thermionic Assembly Laboratory	4-F
138	Mission Operations	5-C
140	Propulsion Materials Storage	4-D
141	Propulsion Materials Storage	4-D
143	Solid Rocket Dock	4-E
144	Environmental Laboratory	4-C
145	Magazine – Propellant	4-E
148	Energy Conservation Laboratory	4-D
149	Energy Conservation Development	4-D
150	25–Foot Space Simulator	4-C
156	Computer Program Offices	5-C
157	Applied Mechanics	6-D
158	Material Research Processing Laboratory	6-D
159	Pump House (water)	4-F
160	Pump House (sewage)	6-D
161	Telecommunications Laboratory	5-C
166	Cooling Tower	4-D
167	Cafeteria	6-C
168	Instrument System Laboratory	7-C
169	Earth Space Science	7-C
170	Fabrication Shop	7-D
171	Material Services	7-D
173	Test Shelter	4-F
175	Water Reservoir	3-F
177	Transportation Garage	5-E
179	Spacecraft Assembly Facility	7-C
180	Administration	6-B
183	Physical Science Laboratory	6-C
184	Electronic Stores	6-D
185	Programming Office	5-C
186	Science Exhibits and Engineering	7-B
187	Chemical Storage	6-E
189	Electronics Laboratory Annex	5-D
190	Procurement Offices	8-C
191	Materials Compatability Laboratory	3-F
195	Guard Shelter	7-C
196	Guard Shelter	5-B
197	Solid Propellant Engineering Laboratory	4-E
198	Control Systems Laboratory	6-D
199	Celestial Simulator	6-D
200	Facilities Engineering and Services	8-C
201	Carpenter Shop	8-C
202	Procurement and Communications Support	7-C
212	Antenna Laboratory	2-D
218	Credit Union	7-C
220	ICS Terminal	6-D
224	Sewage Lift Station	8-C
225	Nitrogen Facility Office	5-D
226	Solvent Storage	5-D
227	Pistol Range Storage	3-B
228	Cooling Tower (A–B)	4-B
229	Shielded Room Building	5-D
230	Space Flight Operation Facility	5-C
231	Paint Shop	8-C
233	System Development	7-C
234	Lumber Storage	8-C
237	Cooling Tower	4-E
238	Telecommunications	5-C
239	Propellant Conditioning Laboratory	4-E
241	Receiving and Shipping	7-D
243	Remote Antenna Range Control	2-C
244	Chemical Engineering	4-E
245	Spectroscopy Laboratory	4-B
246	Safe Test Laboratory	4-D
248	10–Foot Space Simulator	4-C
249	Visitor Reception	6-B
250	Main Guard Shelter	6-B
251	Gyro Laboratory	4-A
252	Guard Shelter	8-B
253	Magnetic Laboratory	4-A
255	Sewage Lift Station	7-C
256	Model Range Control	2-C
257	Main Guard Island	6-B
258	Water Reservoir	3-F
259	Liquid Nitrogen Bottling Storage	5-D
260	Illuminator Equipment	3-B
261	Controlled Storage	8-D
262	Radiometer	2-B
263	First Aid	6-D
264	Space Flight Support	6-C
267	Water Reservoir	3-C
268	Pump House	3-C
269	Grounds Maintenance	7-D
270	Sewage Metering Station	7-B
271	Oil Storage	6-D
272	East Illuminator	3-D
273	Antenna Tower	3-D
274	Cooling Tower (A–B)	7-D
275	Pyrotechnic Storage	4-E
276	Propellant Storage	3-E
277	Isotope Thermoelec. Sys. Appl. Lab.	5-E
278	Robotics Laboratory	6-D
279	Guard Island	7-C
280	Static Test Tower	4-D
281	Fire and Guard Headquarters	6-D
283	Metal Storage	8-D
284	Transportation Office	5-E
285	Arroyo Bridge	4-G
286	Guard Shelter	4-F
287	Guard Island	4-F
288	Project Equipment Storage	4-D
289	Main Sewage Lift Station	7-B
290	Antenna Inspection	2-D
291	Procurement Services	8-C
292	Fire Station	6-D
293	Instrumentation Cable Amplifier Building	6-C
294	Guard Shelter (Visitor Lot)	8-B
295	Antenna Test Facility	2-E
296	Central Cooling Tower Water System	5-D
297	Xenon Test Laboratory	4-C
298	Frequency Standard Laboratory	4-A
299	Assembly Handling & Shpg. Equip. Fac.	4-D
300	Earth and Space Science Laboratory	6-E
301	Central Engineering Building	6-C
302	Microdevices Laboratory	5-E
303	Engineering Support Building	5-E
304	Oleintegrator	6-D

Figure 2-2

Site Facility Map

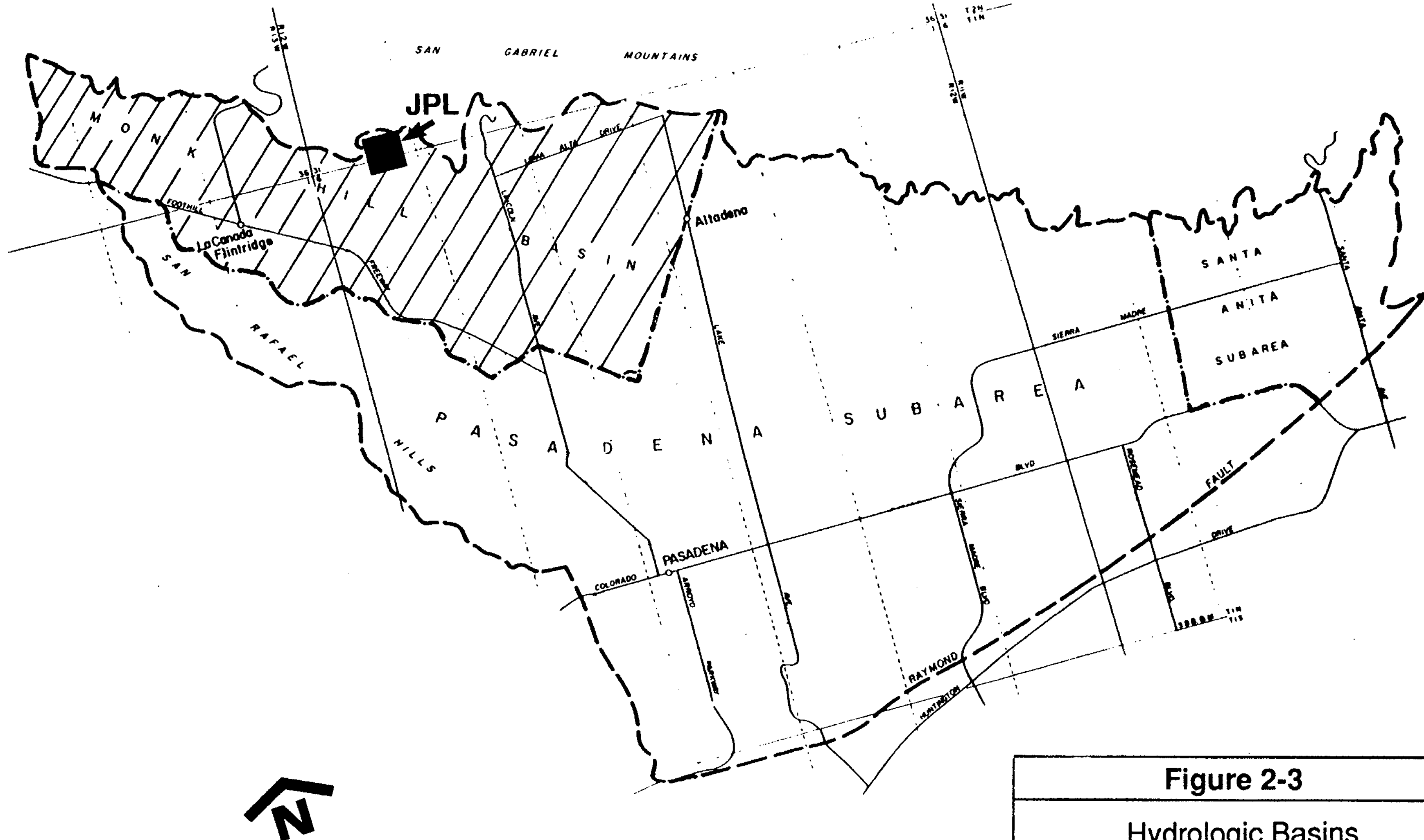


Figure 2-3

Hydrologic Basins
in the Pasadena Area
(Modified from Nagler, 1985)

lower elevations usually encountered between July and December and higher elevations occurring between January and June.

The groundwater table below JPL has been encountered during drilling of monitoring wells at depths from 100 to 240 feet below ground surface. The groundwater table is significantly affected by City of Pasadena water supply wells located within 2000 feet southeast of JPL. Groundwater moves primarily to the southeast from JPL toward these water supply wells. The estimated regional hydraulic gradient in the Raymond Basin is between 200 feet per mile to 100 feet per mile (Raymond Basin Management Board, 1985). The average transmissivity of the underlying aquifer ranges from approximately 50,000 gallons per day per foot (gpd/ft) in the La Canada Valley to about 200,000 gpd/ft near the Arroyo Seco and Devil's Gate Dam (Raymond Basin Management Board, 1985).

The City of Pasadena has three water supply wells and one monitoring well located in the Arroyo Seco downgradient from JPL. The City of Pasadena routinely collects water samples from these wells located in the Arroyo Seco. The analyses of these samples have indicated the presence of small amounts of TCE (trichloroethene), CCl_4 (carbon tetrachloride), PCE (tetrachloroethene) and 1,2-DCA (1,2-dichloroethane).

2.1.2 Geology

JPL is located immediately south of the southwestern edge of the San Gabriel Mountains (see Figure 2-4). The San Gabriel Mountains, together with the San Bernardino Mountains to the east and the Santa Monica Mountains to the west, make up a major part of the east-west trending Transverse Range province of California. This province is dominated by east-west trending folds, reverse faults, and thrust faults indicating a history dominated by north-south compressional deformation.

The San Gabriel Mountains are mainly composed of crystalline basement rocks. These rocks range in age from Precambrian to Tertiary and include various types of diorites, granites, monzonites, and granodiorites with a complex history of intrusion and metamorphism. Immediately north of JPL the

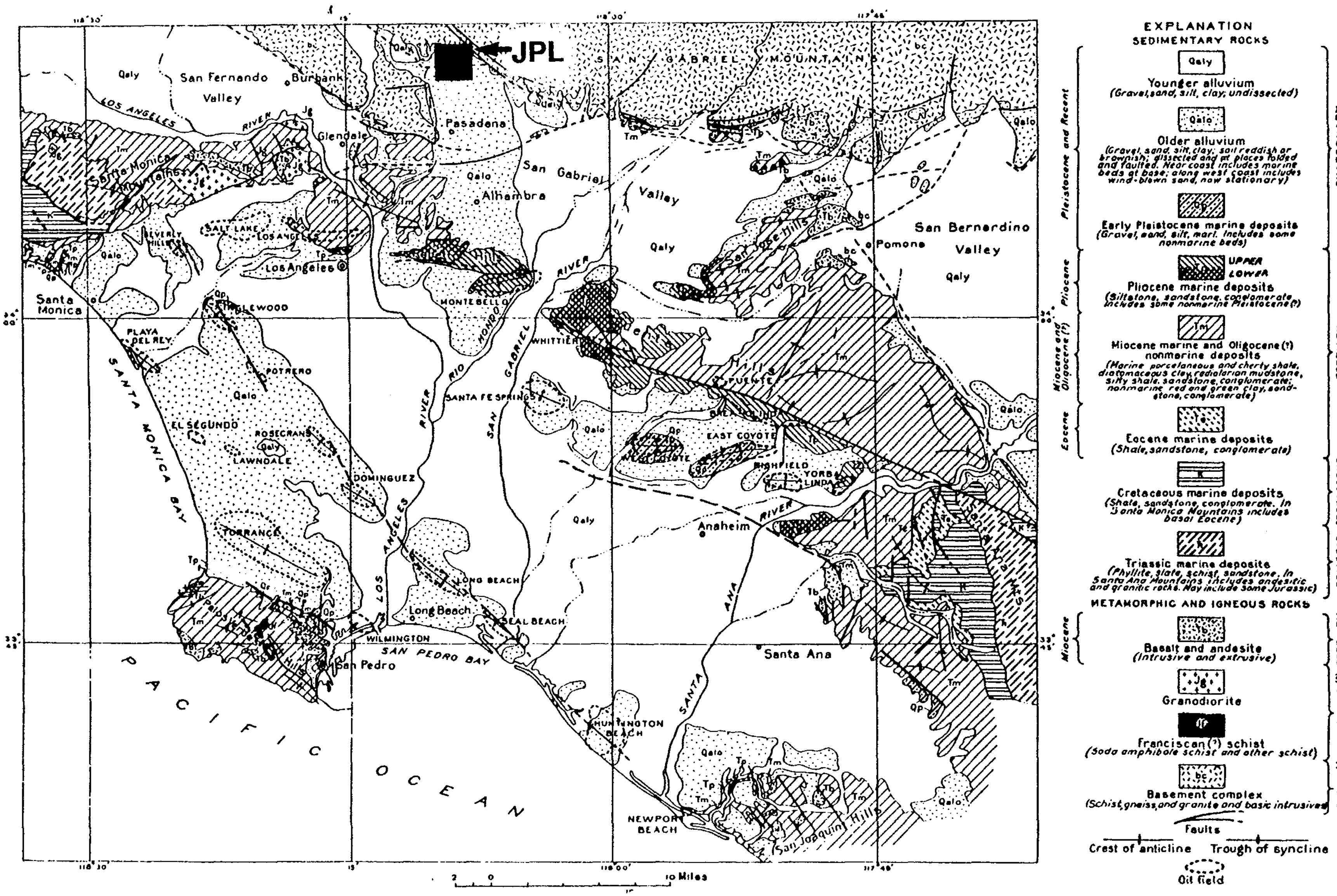


Figure 2-4
Generalized Geologic Map of Los Angeles Basin and Borders
(Conrey, 1967).

San Gabriel Mountains are comprised of the Quaternary Pacoima Formation. This formation is composed of conglomeratic arkosic sandstones of stream channel and fanglomeratic origin (Smith, 1986). The color of the Pacoima Formation is buff or tan where unweathered and ranges from orange to dark reddish orange where weathered.

Periodic tectonic uplift of the San Gabriel Mountains has occurred during the past 1 to 2 million years producing the present topography of the area (Smith, 1986). Most of this uplift has occurred along north to northeast dipping reverse and thrust faults located along the south to southwest edges of the San Gabriel Mountains. As Figure 2-5 shows, thrust faults located near JPL include the Mt. Lukens Thrust Fault, the south branch of the San Gabriel Thrust Fault, and the JPL Thrust Fault (a.k.a. "bridge fault"). East of the Arroyo Seco the south branch of the San Gabriel Thrust Fault is the primary range-front fault. West of JPL the Mt. Lukens Thrust Fault is the main range-front fault, and across JPL the JPL Thrust Fault is the primary range-front fault. These faults, along with others along the southern edge of the San Gabriel Mountains, comprise the Sierra Madre Fault system.

The Sierra Madre Fault system separates the San Gabriel Mountains to the north from the Raymond Basin to the south. The sediments of the Raymond Basin adjacent to and beneath JPL are the result of alluvial and fluvial deposition. Current fluvial deposition can be found in the Arroyo Seco where braided steam-channel deposits are now located. Older quaternary alluvial fan deposits, or fanglomerates, are located beneath JPL. Generally, these sediments are characterized by poorly sorted, poorly consolidated, coarse grained, brown sands with gravels, cobbles and boulders. The cobbles and boulders are primarily subrounded and can get up to 3 feet in diameter. The San Gabriel Mountain crystalline basement complex is clearly the provenance of the cobbles and boulders. The fanglomerates also contain significant amounts of clay and silt. Bedding is very poorly developed in the fanglomerates where the percentages of silt, clay, cobbles, and boulders fluctuate throughout the stratigraphic column. These fanglomerates reach a maximum thickness of approximately 750 feet near JPL and the mouth of the Arroyo Seco and gradually thin to the south. Figure 2-6 is a contour map on top of the crystalline basement complex near JPL showing the general dip of the basement.

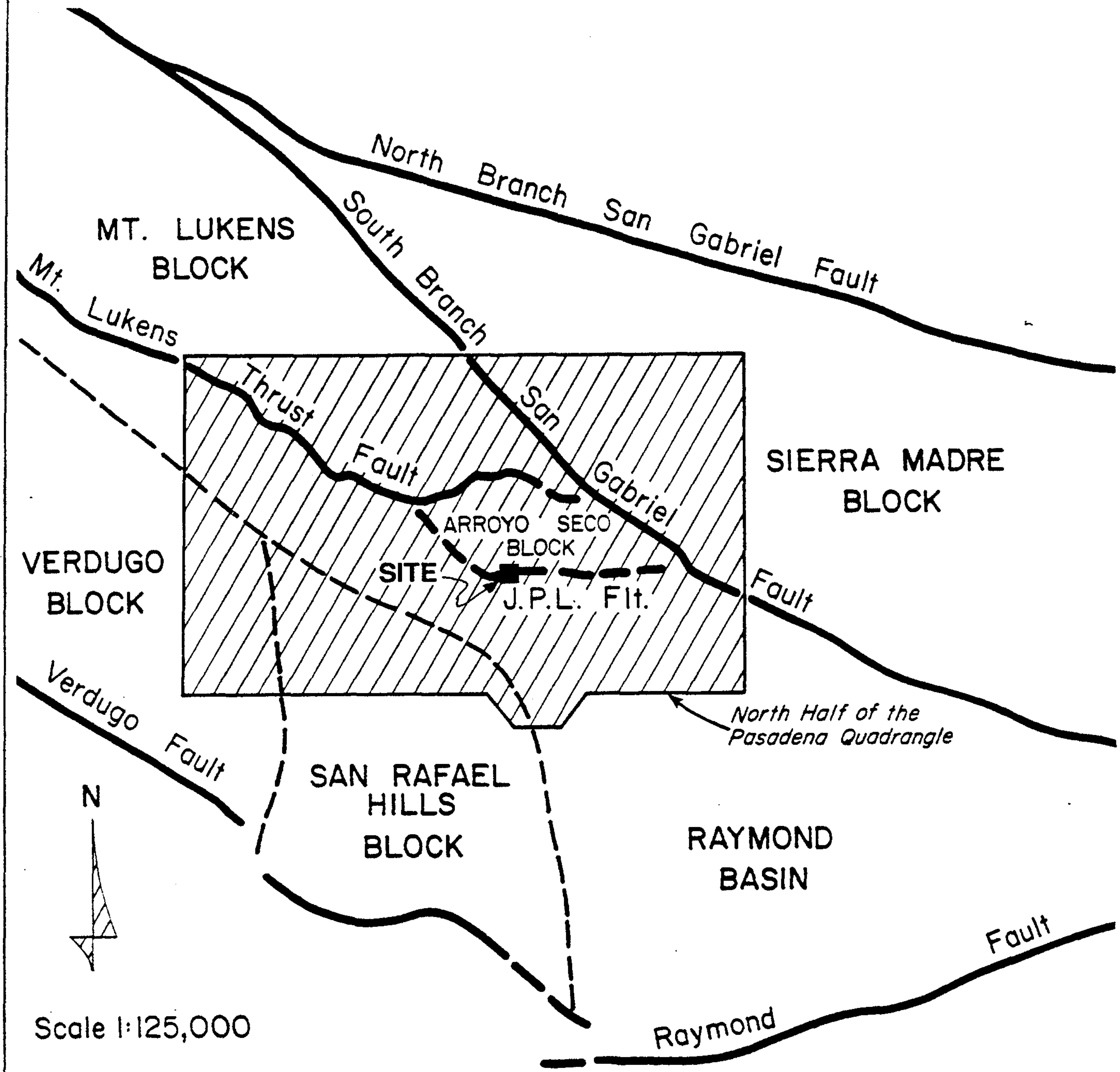
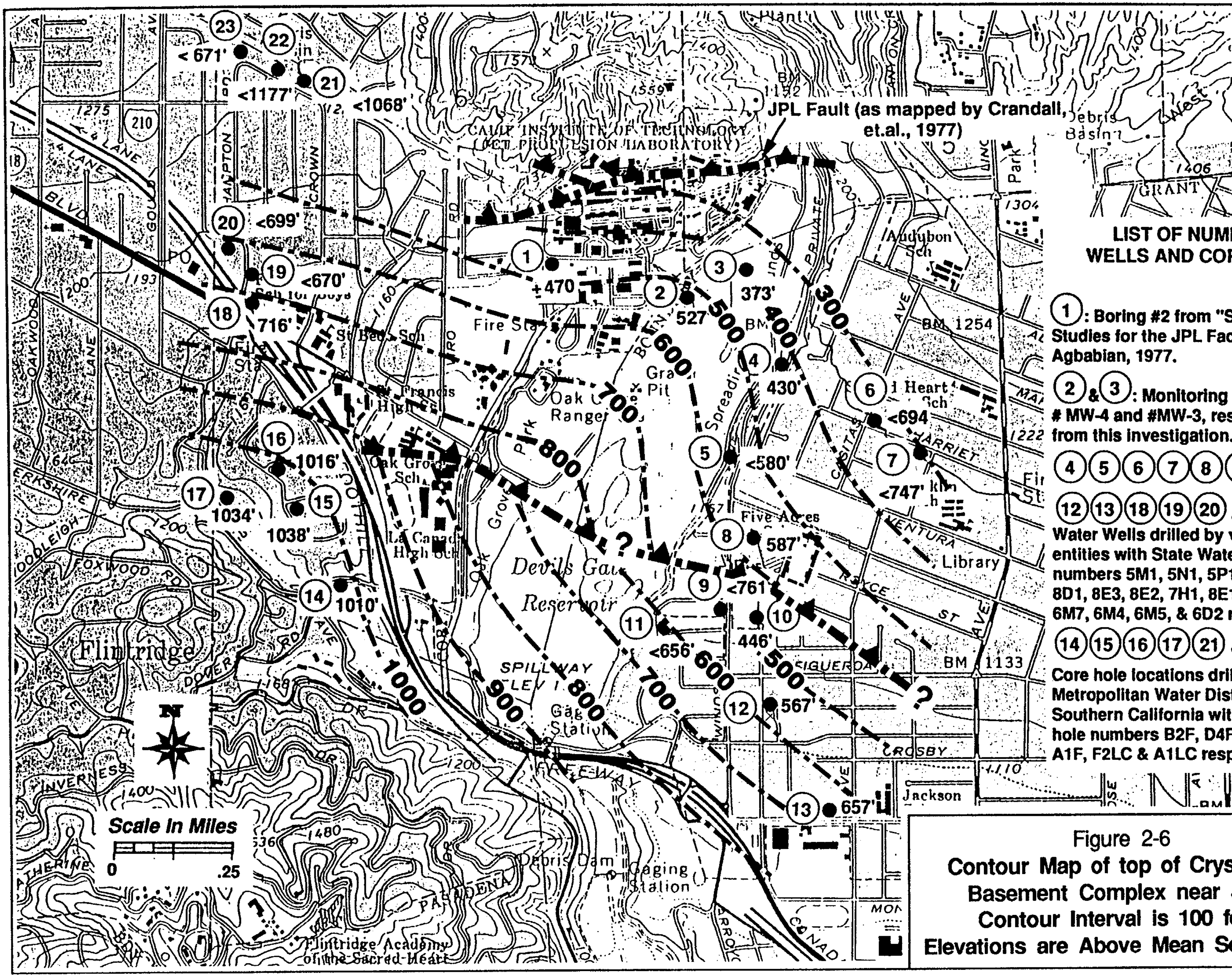


Figure 2-5
General Location of the Principal Structural Blocks and Faults near JPL. (Smith, 1986)



LIST OF NUMBERED WELLS AND CORE HOLES

(1): Boring #2 from "Seismic Studies for the JPL Facilities". Agbabian, 1977.

(2) & (3): Monitoring Wells # MW-4 and #MW-3, respectively from this investigation.

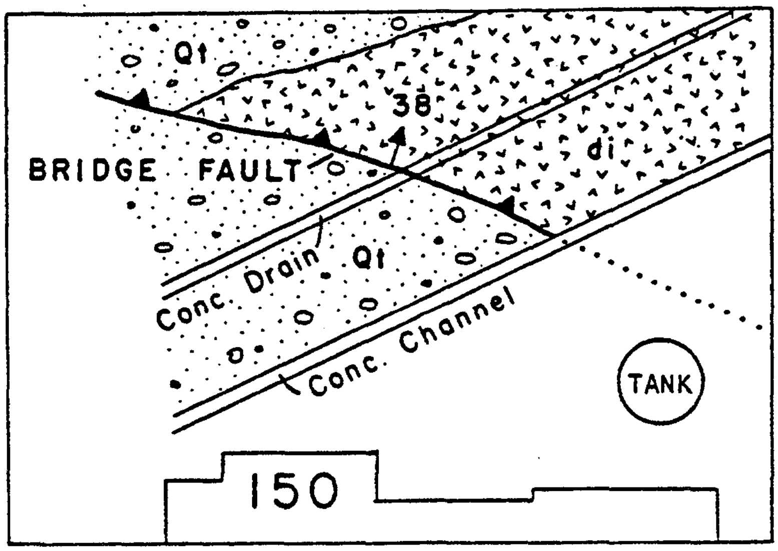
(4) (5) (6) (7) (8) (9) (10) (11) (12) (13) (18) (19) (20) & (23): Water Wells drilled by various entities with State Water Well numbers 5M1, 5N1, 5P1, 5P2, 8D1, 8E3, 8E2, 7H1, 8E1, 8L2, 6M7, 6M4, 6M5, & 6D2 respectively.

(14) (15) (16) (17) (21) & (22): Core hole locations drilled by Metropolitan Water District of Southern California with core hole numbers B2F, D4F, D5F, A1F, F2LC & A1LC respectively.

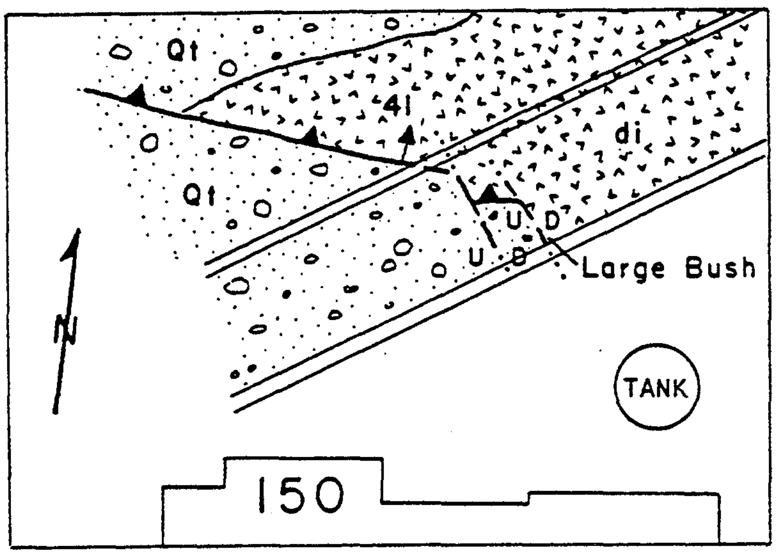
Figure 2-6
Contour Map of top of Crystalline Basement Complex near JPL. Contour Interval is 100 feet. Elevations are Above Mean Sea Level.

During the Expanded Site Inspection of JPL (Ebasco, 1990a), Ebasco geologists performed a reconnaissance survey of the surface geology accessible at JPL. Of particular interest were the exposures of the JPL Thrust Fault. In 1977, Agbabian Associates completed a seismic study of JPL and mapped the JPL Thrust Fault. Figure 2-7 shows the trace of the JPL Thrust Fault behind Building 150 as mapped by Agbabian Associates (1977) and as previously mapped by Converse, et al. (1971). After visiting this area, Ebasco concluded that the general geometry of the fault trace more closely resembled that as mapped by Agbabian Associates, although Ebasco could not confirm the locations of the two small normal faults mapped by Agbabian Associates. The traces of these normal faults may have been covered by the thick natural vegetation currently on the hillside. Ebasco also field checked and confirmed the location of the JPL Fault exposed near Buildings 98 and 134 west of the present bridge across the Arroyo Seco. At this location the trace of the JPL Thrust Fault can be found at the contact between granitic alluvium at the foot of the hill behind JPL and the crystalline basement (diorite at this location) above it.

The amount of influence, if any, faults on and near JPL have on the movement of groundwater is not currently known. More detailed data regarding groundwater elevations adjacent to faults are needed to evaluate the role they may, or may not, play in groundwater movement. It is possible the fault planes present on JPL do not influence local groundwater movement since sandy alluvium has apparently been faulted adjacent to similar sandy alluvium without appreciable fault gouge. Behind Building 150 at the northern edge of the facility, north of the JPL Fault, three shallow wells were installed as part of a soil dewatering system. Details of the dewatering system are presented in the following section describing previous investigations. During the drilling of these three wells, crystalline basement rocks were drilled into from 2 to 20 feet below grade and groundwater was found to be from ground level down to 4.5 feet below ground level. South of the JPL Fault, monitoring well EMW-7 (installed during the ESI, Ebasco, 1990a) penetrated the water table at 236 feet below grade and never did reach crystalline basement when drilling stopped at 270 feet. It is therefore likely local groundwater movement is influenced by the depth and geometry of the crystalline basement complex which is influenced by the



(a) As mapped by Converse, et al., 1971



(b) As mapped by Agbabian Associates, 1977

0' 50' 100'

Qt = QUATERNARY TERRACE DEPOSIT

di = DIORITE

38, 41 = DEGREES OF FAULT INCLINATION FROM THE HORIZONTAL

U = RELATIVELY UPWARD DISPLACEMENT OF FAULT WALL

D = RELATIVELY DOWNWARD DISPLACEMENT OF FAULT WALL

Figure 2-7

JPL Fault as Mapped Behind JPL Building 150 (Agbabian, 1977)

fault system. The shallow groundwater north of the JPL Fault is likely the result of the shallow basement north of the JPL Fault and may not be related to a potential fault gauge barrier formed along the JPL Fault plane. Again, more data on groundwater elevations adjacent to faults at JPL are needed to accurately determine the influence faults have on local groundwater movement.

2.2 PREVIOUS INVESTIGATIONS

Numerous investigations focusing on geotechnical issues and previously identified environmental issues have been conducted at JPL in the past. JPL contains many buildings that host, or have hosted, various laboratory experiments. From 1945 to 1960, cesspools and open areas around JPL were apparently used to dispose of a variety of materials. Investigations of VOC content in nearby monitoring and water production wells have suggested that JPL may be a source of the VOCs.

Geotechnical and environmental studies on JPL and the Arroyo Seco have been conducted sporadically over the past 13 years and include:

- Agbabian Associates, 1977
- LeRoy Crandall and Associates, 1981
- Geotechnical Consultants, Inc., 1982
- Richard C. Slade, 1984
- James M. Montgomery, 1986
- Ebasco Environmental, 1988a, 1988b
- Geotechnical Consultants, 1989
- Ebasco Environmental, 1990a
- Ebasco Environmental, 1990b

The following discussions briefly summarize of each of these studies.

Agbabian Associates, 1977

A three part seismic study of JPL conducted by Agbabian Associates was completed in 1977.

Part I, A Study of Seismic Criteria for the Jet Propulsion Laboratory Facilities, provided a state-of-the-art reappraisal of the input criteria developed in 1972 for evaluating the earthquake resistance of JPL facilities. This report also provided a reevaluation of the JPL Thrust Fault, updated data on seismicity, and summarized recent subsurface investigations conducted at the site.

Part II, Supplemental Geologic Studies for the Jet Propulsion Laboratory Facilities, reported on additional geological studies recommended to be conducted in Part I, which included trenching to locate materials suitable for dating the most recent activity along the JPL Fault.

Part III, Implications of Fault Hazard for the Jet Propulsion Laboratory Master Plan, discussed recommendations for the use of existing facilities and the development of land within a zone of potential earthquake ground breakage on the property.

LeRoy Crandall and Associates, 1981

In 1981, LeRoy Crandall and Associates performed an evaluation of a soil dewatering system installed for JPL around Building 150. The water wells were installed by Barney's Hole Digging Service, Inc. and were logged by a LeRoy Crandall and Associates field geologist.

The dewatering system consisted of one 12-inch diameter, 60-foot deep pumping well, and two 4-inch diameter 40-foot deep observation wells installed 40 feet and 80 feet away, respectively, from the pumping well.

Based on a performance record of about three months, the system appeared to be removing significant quantities of water north of the building; however, the entire area had not been dewatered as indicated by water levels in the observation wells. The water level in Observation Well No. 1, located a distance of 40 feet from the pumping well, had declined three feet during this period of time, and the water level in Observation Well No. 2, located 80 feet from the pumping well, had declined less than 0.5 feet.

Recommendations made by LeRoy Crandall and Associates included modifying the operation of the pumping well to increase its area of influence and converting the observation wells into pumping wells.

Geotechnical Consultants, Inc., 1982

In 1982, Geotechnical Consultants, Inc. (GTC) conducted a preliminary hydrologic assessment of potential volatile organic contamination in the groundwater in the Arroyo Seco for the City of Pasadena. This investigation included the installation of a groundwater monitoring well, groundwater sampling, and chemical analysis of water samples. A final report was not submitted to the City of Pasadena because the appropriated budget had been exceeded before the project was completed. Ebasco obtained information on this investigation from a City of Pasadena Water and Power Department open file.

The GTC investigation included the drilling of a monitoring well, labeled MH-01, to a depth of 399 feet. Well MH-01 is located in Arroyo Seco approximately half way between one of Pasadena's water supply wells (Arroyo Well) and JPL Building 103. It was believed that the source of the volatile organic contamination in the Arroyo Well was a former waste disposal pit located near JPL Building 103. A 9 7/8-inch boring was cased to a depth of 366 feet with 6-inch PVC blank casing and 6-inch slotted PVC casing. The well was screened at nine different intervals between the depths of 145 feet and 355 feet (without any separation between the screened intervals). A sandpack was placed continuously from 366 feet to approximately 100 feet below ground level.

Standard decontamination procedures were employed to minimize contamination from well construction materials, drilling and sampling equipment. Soil and groundwater samples were collected from different depths in the boring and the well, respectively. Water samples were collected using syringes and by pumping. Samples were analyzed by Montgomery Laboratories for volatile organics, trihalomethanes/synthetic organics, pesticides, PCBs and herbicides. Analyses of the water samples showed concentrations of carbon tetrachloride (CCl_4), trichloroethene (TCE), and tetrachloroethene (PCE) were present above drinking water standards. Concentrations of CCl_4, TCE and PCE ranged from non-detected (ND) to 17 ppb, ND to 59 ppb, and 0.1 to 2.5 ppb, respectively.

Richard C. Slade, 1984

A preliminary assessment of soils and groundwater at JPL was prepared by R. C. Slade in 1984. The purpose of this report was to provide JPL with a preliminary hydrogeologic assessment of quantitative results of laboratory analyses of soil and water samples collected on or near JPL.

This investigation involved trenching at two abandoned cesspools at JPL and groundwater sampling from City of Pasadena monitoring well MH-01. The cesspools investigated are located southwest of Building 59 and southwest of former Building 65. Both buildings were used in the past for chemistry experiments.

Exploration of these former cesspools consisted of digging several trenches at each site, logging the trenches and collecting soil samples for laboratory analysis. The trenches were excavated using a two foot wide backhoe and ranged in depth from 8 to 13 feet. None of the trenches were excavated to the bottom of the cesspools. Soil samples were collected from depths ranging from 1 to 9-1/2 feet. Soil samples were analyzed for CCl_4, TCE, PCE, 1,1,1-TCA, priority pollutant metals, chromium, fluoride, and pH.

The groundwater investigation included collecting water samples from the nine different screened intervals in Monitoring Well MH-01. The report noted that the well was not purged before sampling. Laboratory water quality tests conducted on each of the samples included analyses for metals, fluoride, cyanide, hexane, TCE, PCE, CCl_4 and 1,1,1-TCA.

Laboratory analyses on soil samples collected from the trenches did not detect any volatile organic compounds. Lead was detected in a concentration of 200 ppm in one trench at a depth of seven feet. The source of this lead was not determined.

Laboratory results of water samples collected from Well MH-01 indicated some metals were present in concentrations below State of California maximum concentration levels (MCLs) for drinking water. Mercury was present in the sample collected from the 182 foot depth in a concentration above its MCL. Fluoride was present in concentrations below its MCL except in the water samples collected from depths of 234 feet and 265 feet (13 and 14 mg/l respectively). PCE was found in all samples and ranged in concentration from 0.2 to 0.7 ug/l. TCE and CCl_4 were found only in samples collected below 265 feet. Concentrations of TCE and CCl_4 ranged from 1.3 and 0.2 ug/l to 7.5 and 2.4 ug/l, respectively.

James M. Montgomery, 1986

During 1986, James M. Montgomery conducted an evaluation of contaminant transport of volatile organic compounds (VOC) in the groundwater in the Arroyo Seco for the City of Pasadena. The objectives of this evaluation were to:

- o Estimate the location of the source of contamination;
- o Estimate the rate and direction of contaminant plume movement; and
- o Estimate the maximum expected contaminant levels (MECs) that might be anticipated in the contaminated wells.

Montgomery relied upon previous data collected by either the City of Pasadena Water and Power Department or by the Regional Water Quality Control Board. Their analyses and evaluations relied upon many assumptions and limited data.

The report concluded that the contamination in the City of Pasadena Arroyo Well appeared to originate from a source located north-northwest of the well. Based on review of historical data and parameter estimation, the VOCs were from a source that originated less than 5000 feet from the Arroyo Well.

To permit accurate predictions of MECs, the locations of contaminant sources and a detailed understanding of the subsurface hydrogeology was needed. This information was not available to Montgomery for their study and therefore MEC predictions were based on limited information and several assumptions. The predictions suggested that MECs for VOCs of about 170 ug/l could be expected at the City of Pasadena Arroyo Well providing current trends continued. They noted, however, that depending upon the precise location and strength of the contaminant source, higher concentrations could be observed.

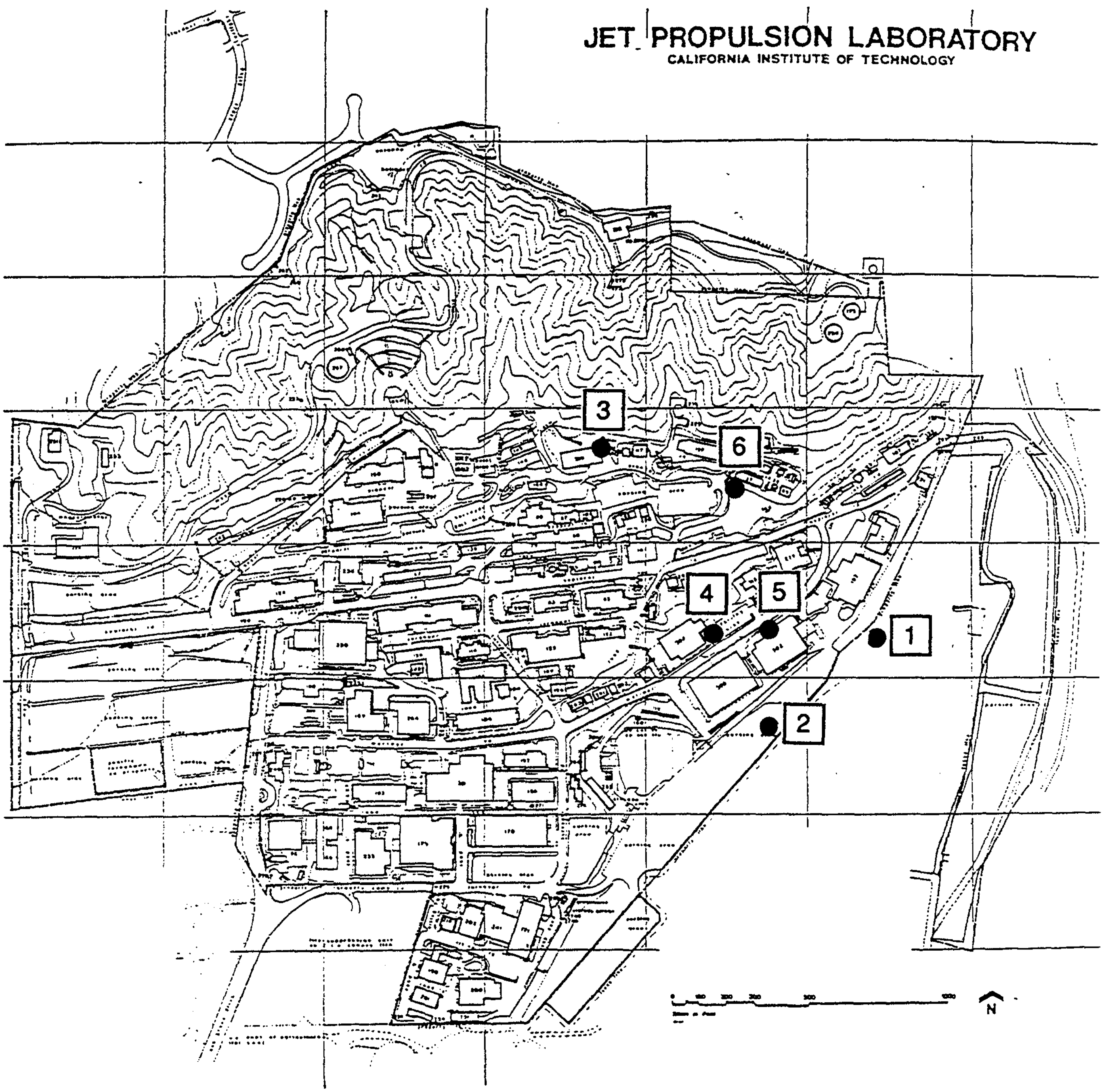
Review of pumping records from water production wells in or near the Arroyo Seco, together with rainfall data suggested that pumping of the City of Pasadena Arroyo Well was perhaps preventing contaminants migrating to the south and southeast of the well.

Information available to Montgomery suggested that JPL was the likely source for the contamination at Lincoln Avenue Water Company Wells No. 3 and No. 5 located in Altadena. Montgomery estimated that the summed concentrations of VOCs could increase to about 150 ug/l in these wells. Again it was stressed that analyses were based on limited data and numerous assumptions. It was also suggested that all public water wells within a two-mile radius of the Arroyo Well be monitored for VOCs at least quarterly.

Ebasco Services Incorporated, 1988a, 1988b

A Preliminary Assessment (PA) and a Site Inspection (SI) as mandated by the EPA was performed at JPL by Ebasco in 1988 (Ebasco 1988a, 1988b). The reports included summaries outlining areas of concern and recommendations for further studies. The PA/SI reported on abandoned waste seepage pits, past chemical spills, and nearby municipal water supply wells. A preliminary Hazardous Ranking System score was computed by Ebasco for JPL following completion of the investigations.

The PA/SI report discussed six pits or old waste disposal sites on and adjacent to JPL property (Figure 2-8). The pits ranged from 15 to 30 feet wide and 15 to 30 feet deep, and were used between 1945 and 1960 for disposal of municipal wastes, and solid and liquid hazardous wastes. Some of the pits were investigated by R. C. Slade in 1984 (discussed previously). Lead in a concentration of 200 ppm was found in one of these pits. Below is a summary of each of the pits or waste disposal sites as discussed in the PA/SI:



Legend:

● Suspected Seepage Sites used for waste disposal

Figure 2-8
Suspected Seepage Sites as Identified in the Preliminary Assessment/Site Inspection (From: Ebasco, 1988a, 1988b)

- Seepage Pit #1. Located near Building 103 (see Figure 2-8, #1). The area is located outside of the JPL property line in the Arroyo Seco dry wash at the southeast corner of the lab. This area was approximately 15 feet in diameter and was used primarily for disposal of municipal solid wastes. However, according to JPL personnel, chemical wastes were also disposed here including solvents, freon, mercury, liquid and solid rocket propellants, cooling tower chemicals, and sulfuric acid. No sampling of this pit had been conducted prior to this study to verify types or current depths of contamination.

- Seepage Pit #2. Located in the south parking lot (see Figure 2-8, #2) south of Buildings 300 and 302. This pit was approximately 30 feet wide and 15 feet deep. Wastes disposed at this pit were similar to those disposed of at Pit #1. The site was also used for burning debris and for disposal of fluorescent lights and scrap magnesium. No sampling of this pit had been conducted prior to this study to verify types or current depths of waste.

- Seepage Pit #3. Located near Building 299 (see Figure 2-8, #3). The pit was 5 to 10 feet wide and approximately 30 feet deep, and was used primarily for the disposal of propellants and mixed solvents. No sampling of this pit had been conducted prior to this study.

- Seepage Pit #4. Located near Building 303 (see Figure 2-8, #4). This pit was apparently used for the disposal of chemistry lab wastes. This pit location was investigated down to a depth of 11 feet in 1984 by R.C. Slade (Slade, 1984). Lead in a concentration of 200 ppm was found in the soil. No other contaminations were found.

- Seepage Pit #5. Located near Building 302 (see Figure 2-8, #5). This pit was also apparently used for the disposal of chemistry lab wastes. R.C. Slade also investigated this pit in 1954 (Slade, 1984) and did not find any contaminants in the soil down to the 11 foot depth.

- o Seepage Pit #6. Located near Building 97 (see Figure 2-8, #6). This is apparently near a former chemistry lab that used this area for disposal of lab wastes. R.C. Slade investigated this area down to 11 feet and no contaminants above background levels were detected (Slade, 1984).

In 1980, analyses of groundwater from of three City of Pasadena water supply wells located down gradient from JPL indicated concentrations of TCE, PCE, and CCl_4 above drinking water standards. In 1982, Geotechnical Consultants, Inc. installed monitoring well MH-01 about half the distance between the three City production wells and JPL. This well detected VOCs in the groundwater in concentrations higher than those detected in the City wells. Geotechnical Consultants concluded that past JPL (and U.S. Army) activities probably contributed to the presence of VOCs. In a study conducted by J. M. Montgomery in 1986, treatment alternatives were evaluated which led to the installation of a pilot treatment plant at one of the four City wells located in the Arroyo.

The data collected during the PA/SI was used by Ebasco to calculate an unofficial Hazard Ranking System (HRS) score for JPL. The resulting preliminary HRS score was 38.3, using the unrevised EPA method of calculation. This was above the 28.5 criteria required in the past for a site to be considered for inclusion on the National Priorities List (NPL).

Geotechnical Consultants, 1989

An evaluation of groundwater quality upgradient of JPL was conducted by Geotechnical Consultants for MARMAC and the U.S. Army Corps of Engineers in 1989. The purpose of this investigation was to install two groundwater monitoring wells upgradient and outside the influence of JPL facility activities. These wells were to be sampled and water quality analyses were to be performed to establish background water quality data for JPL.

Monitoring well CMW-1 was installed just outside the northeast corner of JPL property and monitoring well CMW-2 was installed in the southwest corner of the west parking lot at JPL. These four-inch PVC wells were completed to depths of 162 feet and 179 feet, respectively. The lower 99 feet of CMW-1 and the lower 79 feet of CMW-2 were screened based on electric log interpretations.

Groundwater samples were collected from well CMW-1 and from existing down-gradient monitoring well MH-01. Monitoring well CMW-2 was not drilled deep enough to reach groundwater due to contractual limitations. Water samples collected from CMW-1 and MH-01 were analyzed for volatile and semi-volatile organics, total petroleum hydrocarbons, five target metals, pH, and total dissolved solids. Laboratory results revealed no evidence of organic contamination or elevated levels of the five target metals analyzed for.

The report concluded that CMW-1 was a legitimate upgradient sampling point to JPL and that there is no immediate evidence of groundwater contamination entering the northeast part of the study area along the Arroyo Seco. Due to the configuration of facilities at JPL, well CMW-1 does not provide a complete evaluation of background groundwater conditions across the entire site. The report recommended that an additional upgradient monitoring well be installed along the north side of the facility to intercept shallow subsurface inflow from the adjacent hillside.

Ebasco Services Incorporated, 1990a

From January to March 1990, Ebasco Environmental conducted an Expanded Site Inspection (ESI) at JPL. During the ESI, five groundwater monitoring wells were installed and 38 soil gas collectors were used to collect preliminary data on the extent of chemical components in groundwater and soil. These data were collected to provide additional support and documentation for the Environmental Protection Agency to provide a final Hazard Ranking System score for JPL. Table 2-1 presents specifications on the monitoring wells installed. Two of the monitoring wells were drilled to crystalline basement rock, as deep as 725 feet below ground level, and were completed with multi-post casing systems which allowed for the simultaneous monitoring of five separate water-bearing zones within the aquifer of each well. Groundwater samples were collected and analyzed for volatile organics, semi-volatile organics, California Administrative code Title 22 metals plus strontium, pesticides and PCBs, Total Petroleum Hydrocarbons, and cyanide.

TABLE 2-1

SPECIFICATIONS OF MONITORING WELLS INSTALLED AT JPL DURING THE ESI

FEBRUARY 1990

Well Number	Location	Drilling Method	Total Drilled Depth (ft)	Depth to Bottom of Casing (ft)	Hole Diameter	Surface Conductor	Top of Well Casing Elevation (ft) above MSL	Well Screened Depth Below Land Surface (ft)	Screen Number
EMW-3 (Deep Multi-port Well)	Arroyo Seco	Mud Rotary	730	700	9-7/8"	22'; 10" diameter	1099.82	170-180 250-260 344-354 555-565 650-660	1 2 3 4 5
EMW-4 (Deep Multi-port Well)	JPL South Parking Lot	Mud Rotary	605	559	12-1/4"	18.5; 16" diameter	1082.72	147-157 237-247 318-328 389-399 509-519	1 2 3 4 5
EMW-5 (Shallow Standpipe Well)	JPL South Parking Lot	Air Percussion Hammer	145	140	11"	None	1071.60	85-135	-
EMW-6 (Shallow Standpipe Well)	JPL West Parking Lot	Air Percussion Hammer	247	245	11"	None	1188.46	195-245	-
EMW-7 (Shallow Standpipe Well)	JPL Parking Lot Near Buildings 288 and 290	Air Percussion Hammer	276	275	11"	None	1212.90	225-275	-

The laboratory data indicated that the groundwater at JPL contains volatile organic compounds including carbon tetrachloride, trichloroethene, tetrachloroethene, and 1,1-dichloroethene in concentrations above state and federal regulatory thresholds for drinking water. Low levels (below regulatory thresholds) of chloroform, bromodichloromethane, and dibromochloromethane (all trihalomethanes) were also detected in the groundwater at JPL but were present in the QA/QC water samples collected from the fire hydrant system at JPL. Water from the fire hydrants at JPL was used during field operations (mixing drilling muds, etc.) and is the likely source of the trihalomethanes detected in the groundwater samples. Figure 2-9 shows the locations of the monitoring wells installed during the ESI and the locations of various volatile organic compounds detected during the ESI.

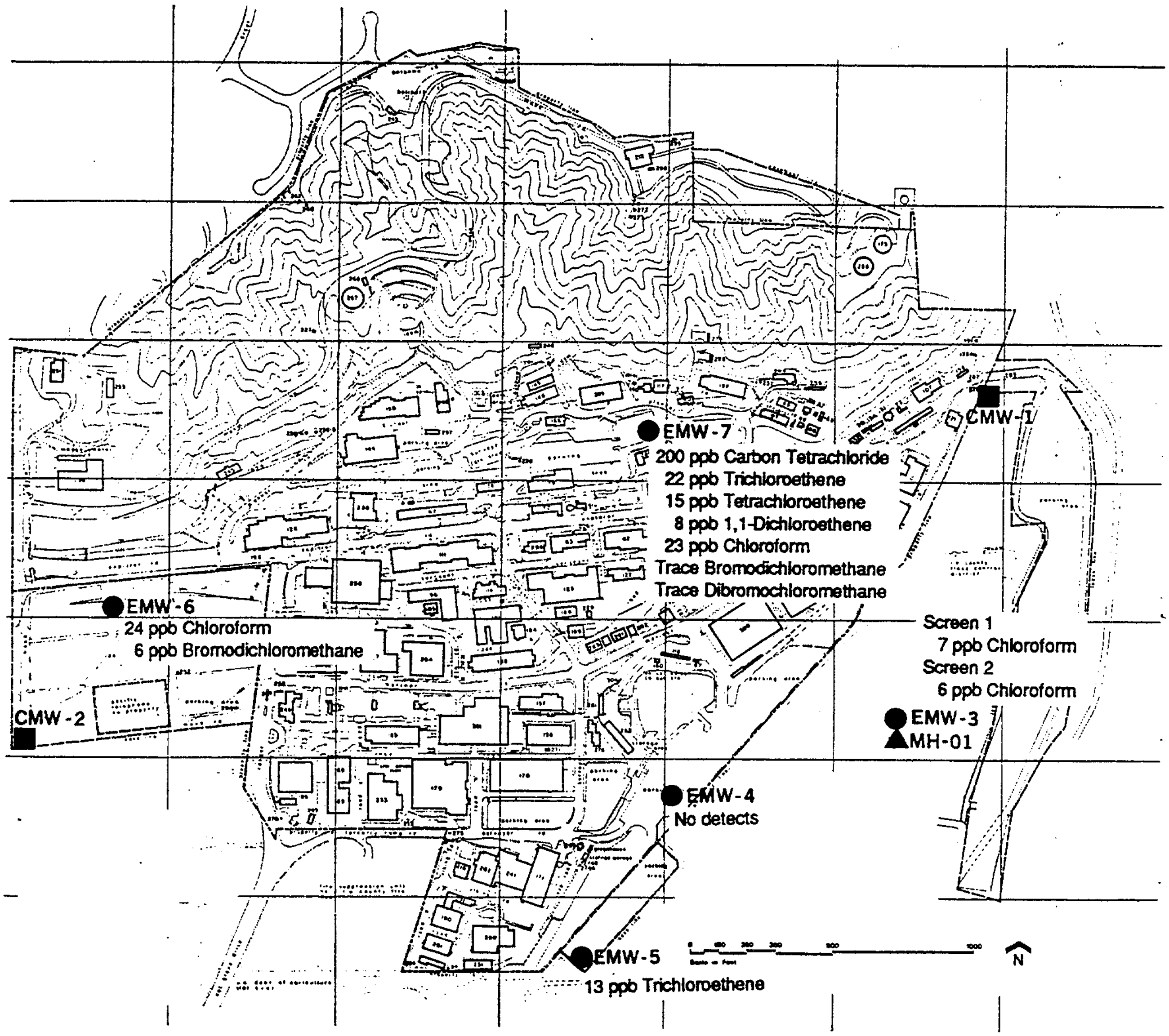
No cyanide, organochlorine pesticides or PCBs were detected in any water sample collected at JPL. The analytical results indicated that metals including antimony, barium, chromium, cobalt, copper, lead, molybdenum, nickel, zinc, and strontium are present in the groundwater of JPL in concentrations well below state regulatory thresholds established for drinking water.

Ebasco Environmental, 1990b

After the Expanded Site Inspection (ESI) of JPL (Ebasco, 1990a) was completed, the Hazard Ranking System (HRS) scoring system methodology was revised by the EPA. The revisions increased the amount and detail of data required by the EPA to evaluate potential threats to public health and the environment while scoring a site for potential inclusion an the National Priorities List (NPL). A report was prepared titled "Supplemental Information to the Expanded Site Inspection Report on the NASA-Jet Propulsion Laboratory" (Ebasco, 1990b) that was intended to present information not previously provided to the EPA so the EPA could complete an HRS score for JPL with the newly revised HRS.

Discussions and data relating to waste characteristics, the groundwater migration pathway, the surface water migration pathway, the air migration pathway, and the onsite exposure pathway were included in this report (Ebasco, 1990b). Brief summaries of these discussions follow:

JPL
Jet Propulsion Laboratory
California Institute of Technology



Legend:

- ● Installed during ESI investigation
- ■ Installed by the Army Corps of Engineers in 1989.
- ▲ Installed by Geotechnical Consultants, Inc. in 1982.

Figure 2-9
Locations of Monitoring Wells Installed and Volatile Organic Compounds Detected During the ESI of JPL

Waste Characteristics:

After the ESI was completed, several long-time JPL employees and retired JPL personnel that were involved in, or had knowledge about, past JPL waste disposal activities and procedures were newly identified and interviewed to further clarify the waste characteristics of JPL. During the interviews, it was learned that of the original six waste pits previously identified in the PA/SI, only two of the pits were apparently constructed solely for regular waste disposal. One of these pits (Pit #2 in PA/SI) was used mainly for glass and metal shaving disposal and the other pit (Pit #3 in PA/SI) was suspected to have been used as a fluorine scrubber. Two other pits identified in the PA/SI (Pits #1 and #6) were apparently not actual "pits", but were open areas where various liquid wastes may have been disposed. The last two pits identified in the PA/SA (Pits #4 and #5) were apparently cesspools used for disposal of liquid and solid wastes. The cesspools were designed to allow liquid wastes to seep into the surrounding soil, and have apparently been referred to as seepage pits in the past. Information gathered during the interviews indicated that all the buildings present at JPL before the current sewer systems were installed (Circa 1960) had cesspools. The cesspools probably received various quantities of chemical wastes since most of the buildings at JPL either stored or used various chemicals, and these cesspools are, or were, important potential sources of soil and groundwater contaminants at JPL.

Ground Water Migration Pathway:

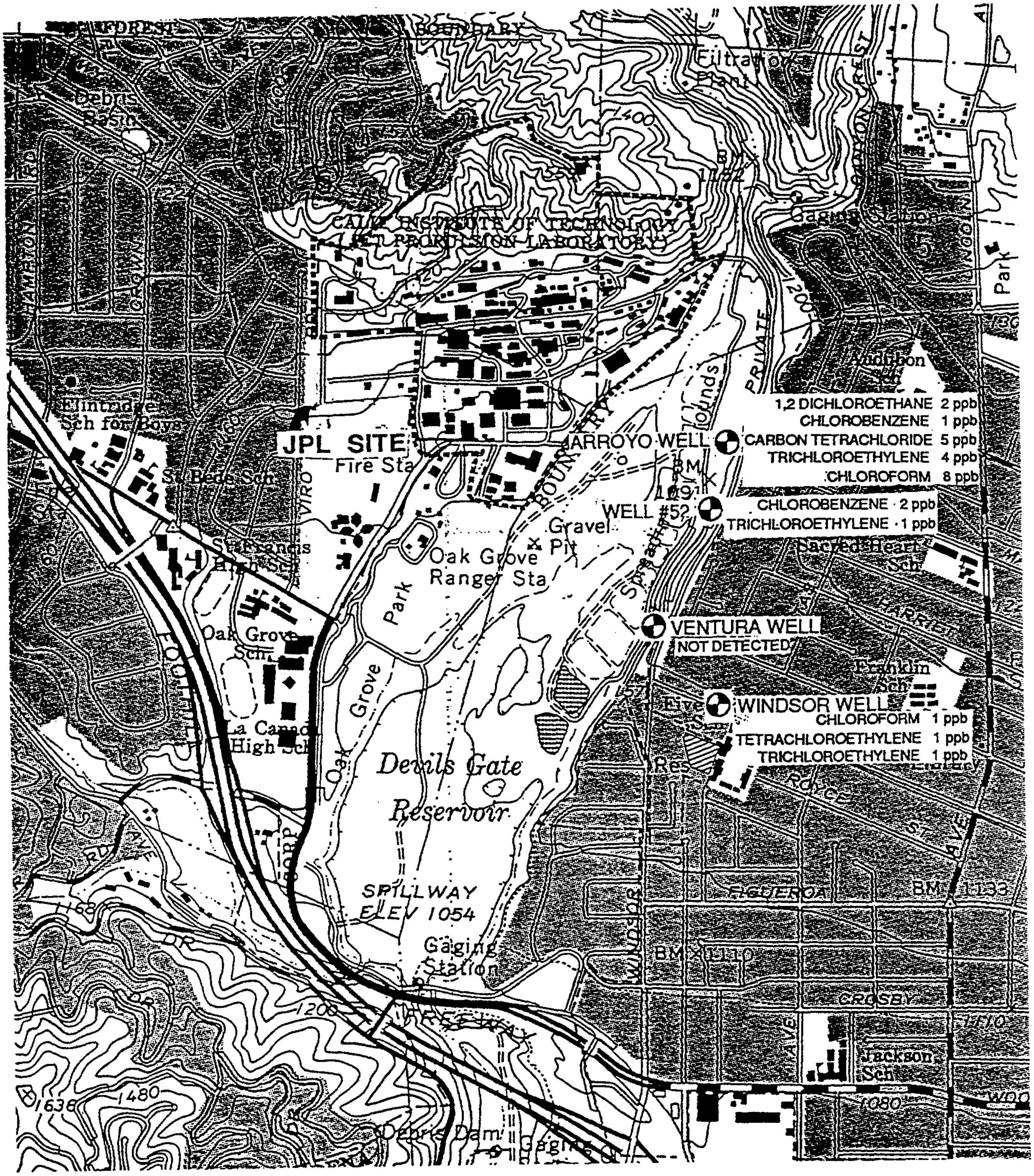
A map was prepared showing the locations of groundwater supply wells within a four-mile radius for JPL and the population potentially served by each well. Copies of the well logs for the City of Pasadena supply wells and JPL monitoring wells were also included. In addition, groundwater sample analyses from a previous round of sampling and a new round of sampling were included.

The analytical results of water samples collected in November 1989 from four City of Pasadena water supply wells (the Arroyo Well, Well #52, the Ventura Well and the Windsor Well) were also included and discussed. The water samples were analyzed for volatile organics (EPA Method 624), semi-volatile organics (EPA Method 625), major dissolved constituents, nitrates, and selected metals including magnesium, copper, iron, manganese, zinc, aluminum, arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver. Figure 2-10 shows the volatile organic compounds detected in each well. The results indicate the volatiles were present in three of the four wells sampled, but in concentrations generally below state and federal drinking water standards. In the Arroyo Well, only carbon tetrachloride and 1,2-dichloroethane were present in concentrations above drinking water standards.

The analytical results of water samples collected in June 1990 from JPL monitoring wells EMW-3 through EMW-7 were also included and discussed. The water samples were analyzed for volatile organics using EPA Method 624, for Na, K, Ca, Mg, Fe, Cl, SO_4, NO_3, CO_3, HCO_3, F, PO_4, Total Organic Carbon (TOC), and Total Dissolved Solids (TDS). Results of the volatile organic analyses are summarized in Table 2-2. The upper two screened intervals of multi-port well EMW-3 contained chloroform at levels below State of California, Department of Health Services drinking water standards. Toluene was detected in Wells EMW-5, EMW-6, and EMW-7 at levels slightly above the analytical detection limit of 5 µg/l. Xylene was also detected in Well EMW-5 at a concentration of 11 µg/l. Several volatile organics were detected in the sample from Well EMW-7, including 1,1-dichloroethene (6 µg/L), trichloroethene (27 µg/L), tetrachloroethene (9 µg/L), carbon tetrachloride (200 µg/L), and chloroform (19 µg/L).

Surface Water Migration Pathway:

Descriptions were provided on the physical characteristics of the ground surface at JPL, JPL's storm drainage system, the physical characteristics and uses of the Arroyo Seco, stream gauging data from the Arroyo Seco, watershed boundaries near JPL, potential targets 15 miles downstream of JPL, and the City of Pasadena's future plans for the Arroyo.



N

PASADENA WELLS

Figure 2-10

Detected Volatile Organic Constituents in the Pasadena City Production Wells, November 1989.

Table 2-2

DETECTED VOLATILE ORGANIC COMPOUNDS IN GROUND WATER SAMPLES COLLECTED DURING THE JUNE 1990 RESAMPLING OF JPL MONITORING WELLS

(Concentrations reported in µg/l)

Well Number	Chloroform	Toluene	Total Xylenes	Carbon Tetrachloride	1,1-Dichloroethene (1,1-DCE)	Trichloroethene (TCE)	Tetrachloroethene (PCE)
EMW-3, screen 1	44	--	--	--	--	--	--
EMW-3, screen 2	6	--	--	--	--	--	--
EMW-3, screen 3	--	--	--	--	--	--	--
EMW-3, screen 4	--	--	--	--	--	--	--
EMW-3, screen 5	--	--	--	--	--	--	--
EMW-4, screen 1	--	--	--	--	--	--	--
EMW-4, screen 2	--	--	--	--	--	--	--
EMW-4, screen 3	--	--	--	--	--	--	--
EMW-4, screen 4	--	--	--	--	--	--	--
EMW-4, screen 5	--	--	--	--	--	--	--
EMW-5	--	6	11	--	--	--	--
EMW-6	--	6	--	--	--	--	--
EMW-7	19	5	--	200*	6	27	9
Primary Standard**	100†	100††	1,750	0.5	6	5	5

Notes:

-- not detected.
* Dilution factor of 2.5.
** Maximum contaminant level established by The State of California, Department of Health Services.
† Total trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, and bromoform).
†† Drinking water action level recommended by The State of California, Department of Health Services.

Surface sediment samples were also collected from the stream channel in the Arroyo Seco. Figure 2-11 shows the locations sampled. After 2 to 3 inches of sediment were removed, sediment samples were collected by driving a 2-inch by 6-inch stainless steel sample tube into the soil with a hand held, sliding hammer drive soil sampler. The sediment samples were analyzed for volatile organics (EPA Method 8240), semi-volatile organics (EPA Method 8270), California Administrative Code Title 22 metals plus strontium (EPA Method 6010/7000), organochlorine pesticides and PCBs (EPA Method 8080), Total Petroleum Hydrocarbons (TPH) (EPA Method 418.1), and cyanide (EPA Method 335.2). Table 2-3 summarizes the analytical results.

No volatile organics, semi-volatile organics, organochlorine pesticides or PCBs were detected in any surface sediment sample. Some metals, cyanide, and TPH were detected in low concentrations.

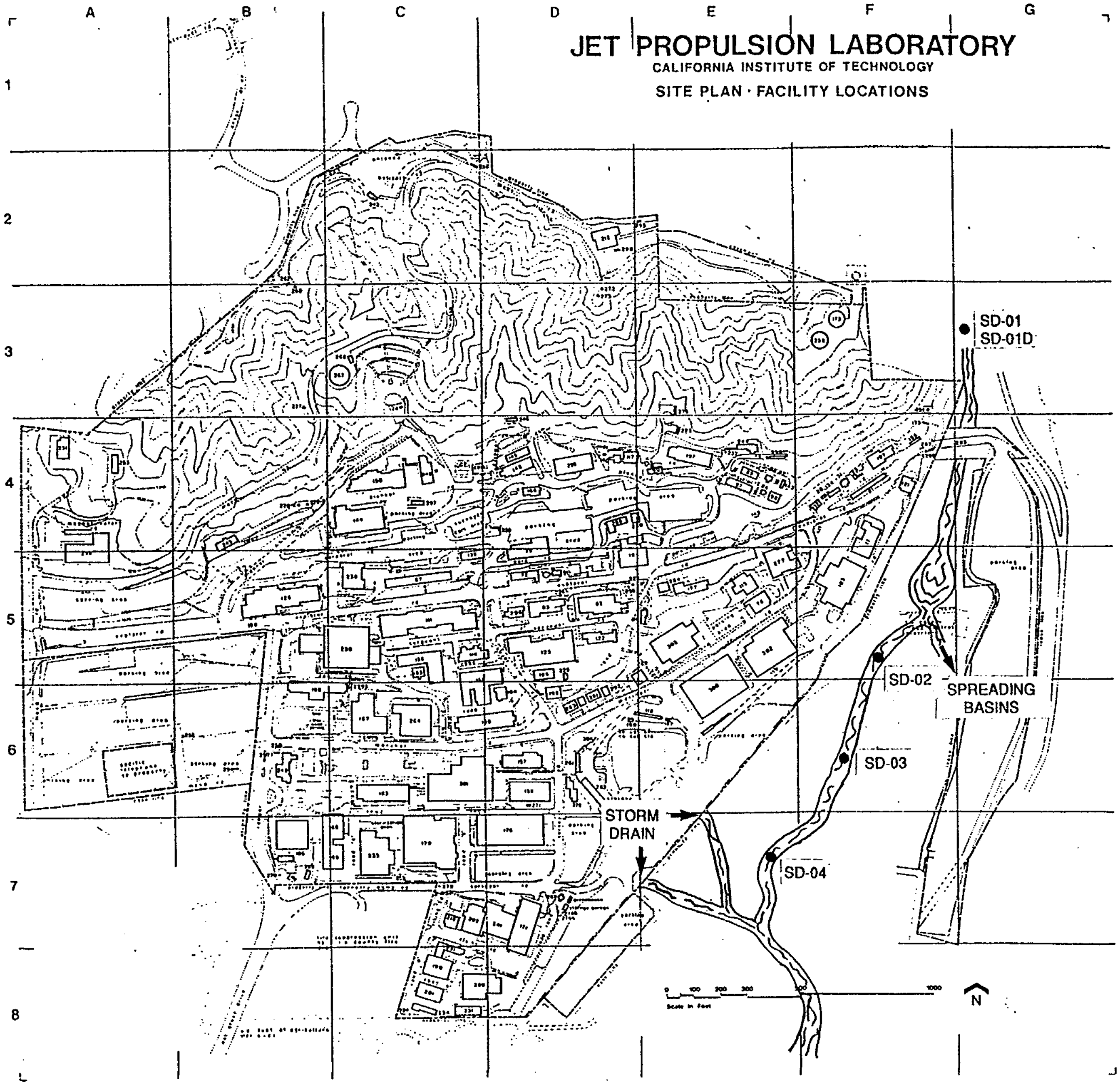
Air Migration Pathway:

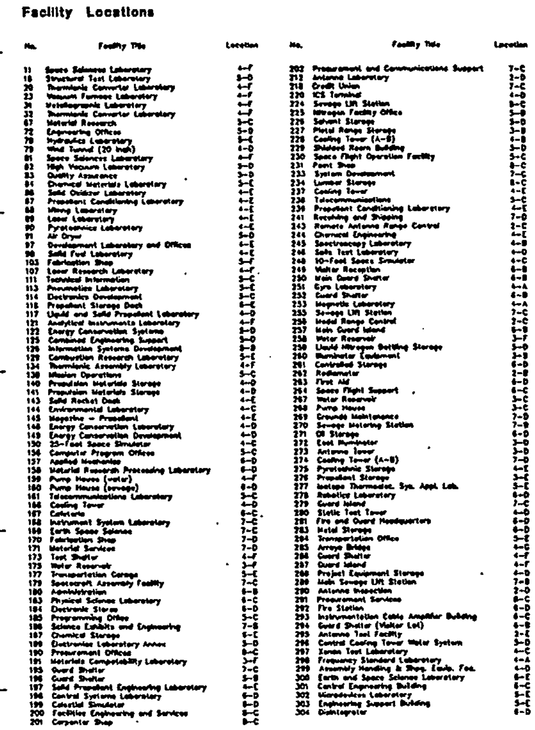
Population counts were provided and land use was presented in concentric rings around JPL at the following intervals: 0 to .25 miles, .25 to .5 miles, .5 to 1 mile, 1 to 2 miles, 2 to 3 miles, and 3 to 4 miles. Table 2-4 shows population counts within these concentric rings around JPL.

Onsite Exposure Pathway:

Target populations of employees working at JPL and within one mile of JPL were presented along with a discussion on access restriction to the site. The resident population within one mile of JPL is estimated to be 6,914. In addition, JPL currently employees approximately 8,000 people.

Since two of the former waste pits identified in the PA/SI (Pits #1 and #2) may have been located wholly or partially outside the current JPL property limits, soil borings were drilled and soil samples were collected to assess the possibility of human exposure to substances that may have been deposited in these pits. Four soil borings were hand augered to 1.5 feet and five soil samples, including a background sample and a QA/QC duplicate sample were collected from 1.5 to 2 feet. Figure 2-12 shows the soil boring locations.





LEGEND:

● SD-01 SEDIMENT SAMPLE LOCATION

Figure 2-11

SURFACE SEDIMENT SAMPLE LOCATIONS (Ebasco, 1990 b)

TABLE 2-3

CONSTITUENTS DETECTED IN SURFACE SEDIMENT SAMPLES COLLECTED
IN THE ARROYO SECO

Sample Locations Shown in Figure 2-11

Constituent	Units	Sample Number					Regulatory Limits *
		SD-01	SD-01D	SD-02	SD-03	SD-04	
Metals							
Barium	mg/kg	23	22	41	75	75	1000
Beryllium	mg/kg	ND **	ND	ND	ND	0.56	7.5
Cadmium	mg/kg	0.5	ND	0.76	1.2	1.2	10
Chromium	mg/kg	2.8	2.8	4.6	8.0	8.4	5600
Cobalt	mg/kg	2.6	2.5	3.9	7.2	7.3	800
Copper	mg/kg	5.3	5.3	13	18	16	250
Lead	mg/kg	16	5.5	15	36	26	50
Mercury	mg/kg	ND	ND	ND	0.13	0.12	2
Nickel	mg/kg	1.2	ND	3.4	4.5	4.3	200
Vanadium	mg/kg	6.3	5.6	9.6	18	19	240
Zinc	mg/kg	18	16	37	69	48	2500
Strontium	mg/kg	20	21	21	61	56	-
Cyanide	mg/kg	ND	ND	ND	ND	0.4	-
Total Petroleum Hydrocarbons	mg/kg	ND	14	71	56	19	-

* 10X Soluble Threshold Limit Concentration (STLC). STLC from California Administration Code Title 22

** Not Detected

TABLE 2-4

POPULATION COUNTS WITHIN CONCENTRIC RINGS AROUND JPL

Radius	Population*	Cumulative Population
0 - 1/4 mi	407	407
1/4 - 1/2 mi	677	1084
1/2 - 1 mi	5830	6914
1 - 2 mi	22,912	29,826
2 - 3 mi	39,547	69,373
3 - 4 mi	51,475	120,848

* Population estimates based on U.S. Census, 1980 Census Test Data (U.S. Department of Commerce, 1983).

TABLE 2-5

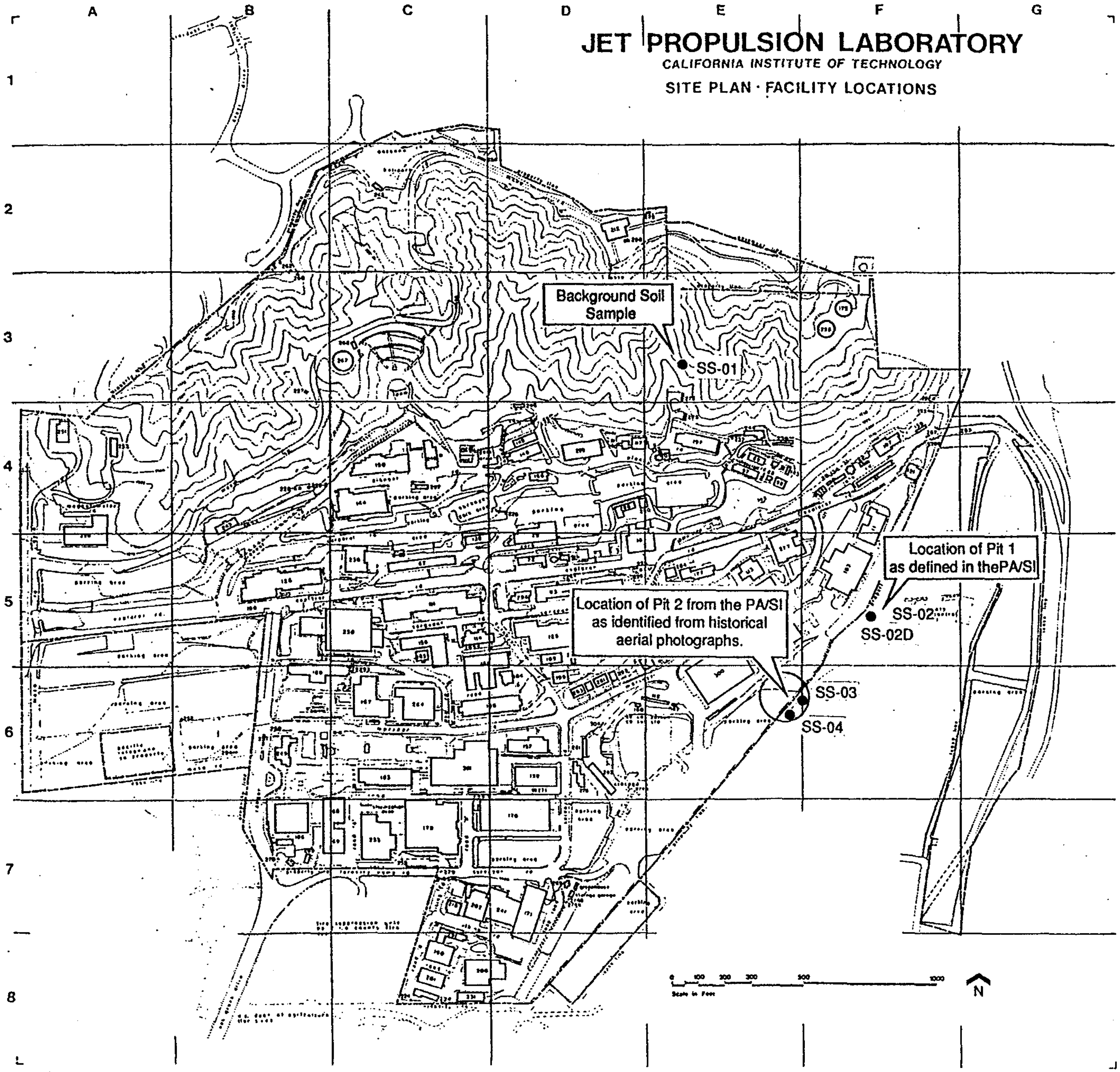
CONSTITUENTS DETECTED IN SOIL SAMPLES COLLECTED ADJACENT TO JPL
(ALL RESULTS IN MG/KG)

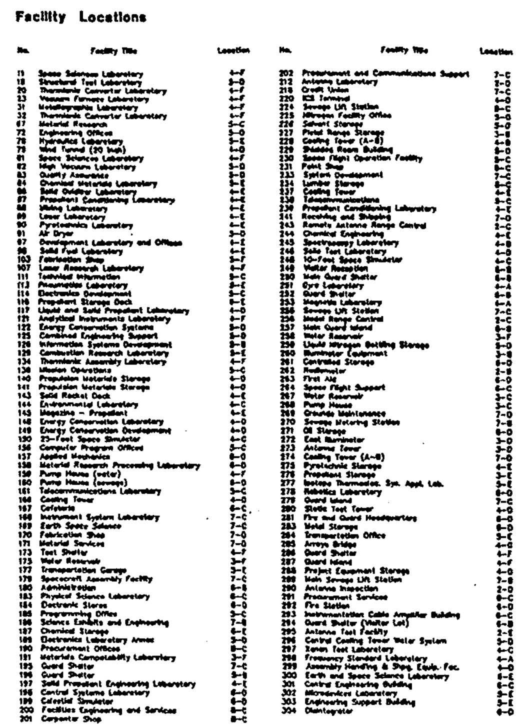
Sample Locations Shown on Figure 2-12

Constituent	Sample Number					Regulatory Limits*
	SS-01	SS-02	SS-02D	SS-03	SS-04	
Metals						
Barium	170	78	110	31	30	1000
Cadmium	1.2	ND**	0.65	0.71	0.62	10
Chromium	2.6	2.3	2.6	4.9	2.7	5600
Cobalt	8.5	4.7	5.6	3.6	2.7	800
Copper	6.1	6.0	6.3	7.0	5.2	250
Lead	ND	4.9	8.0	11	ND	50
Nickel	1.8	1.8	1.9	2.2	1.1	200
Vanadium	15	7.5	11	6.8	5.9	240
Zinc	45	33	29	69	18	2500
Strontium	21	14	19	13	20	-
Total Petroleum Hydrocarbons	ND	12	ND	29	ND	-

* 10X Soluble Threshold Limit Concentration (STLC). STLC from California Administration Code Title 22.

** Not Detected.





LEGEND:

● SD-01 SOIL SAMPLE LOCATION

Figure 2-12

SOIL SAMPLE LOCATIONS (Ebasco, 1990 b)

The soil samples were analyzed for volatile organics (EPA Method 8240), semi-volatile organics (EPA Method 8270), California Administrative Code Title 22 metals plus strontium (EPA Methods 6010/7000), organochlorine pesticides and PCBs (EPA Method 8080), Total Petroleum Hydrocarbons (TPH) (EPA Method 418.1), and cyanide (EPA Method 335.2). Table 2-5 summarizes the analytical results.

No volatile organics, semi-volatile organics, organochlorine pesticides, PCBs, or cyanide were detected in any soil sample. Some metals and TPH were detected in low concentrations.

2.3 PRELIMINARY RISK EVALUATION

A preliminary risk evaluation for the JPL site contaminants identified in previous studies has been conducted as part of this Work Plan effort to:

- o Provide a summary of the potential human health hazards posed by previous activities at the site,
- o Characterize potential hazards in terms of a qualitative conceptual model that will serve as a basis for a baseline health risk assessment,
- o Provide an overview of the potential hazards to wildlife, and
- o Identify important data gaps to be addressed to complete a quantitative endangerment assessment (EA).

This preliminary risk evaluation has been segregated into these general areas of concern.

The potential human health hazards posed by previous activities at JPL is summarized in Figure 2-13. Figure 2-13 is a conceptual volatile organic compound exposure model for JPL.

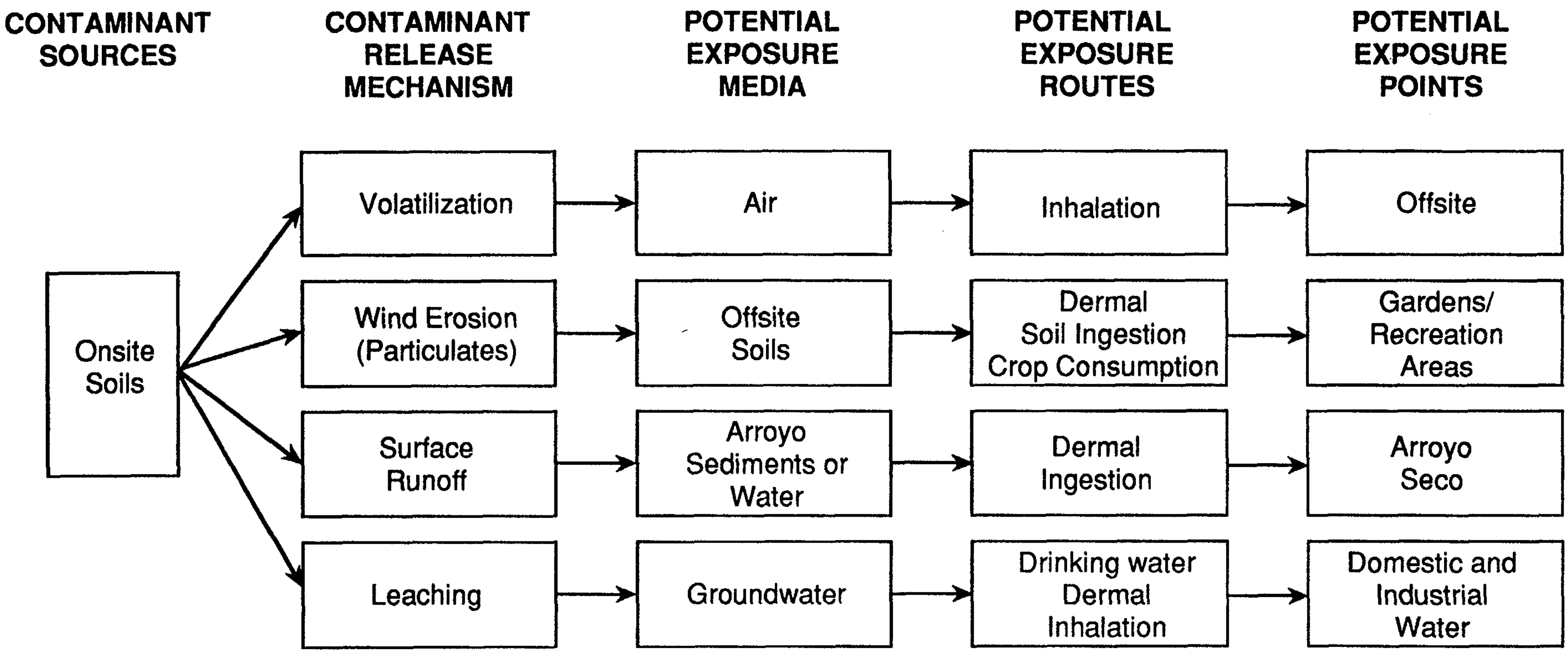


Figure 2-13

Conceptual Volatile Organic Compound Exposure Model for the Jet Propulsion Laboratory, Pasadena, CA

The existing site characterization data indicate that groundwater underlying the site contains a variety of VOCs. A preliminary soil gas study along with several interviews with JPL personnel indicate there is a strong possibility that some VOCs may have been disposed of in subsurface pits or structures. The nature of conditions present in these subsurface features is currently unknown, however it is not believed that these VOCs are currently exposed at the surface.

The VOCs identified to date in groundwater samples collected have included:

Carbon Tetrachloride
Chlorobenzene
1, 2 - Dichloroethane
1, 1 - Dichloroethene
1, 1, 2 - Trichloro - 1, 2, 2, - Trifluoroethane (Freon 113)
Tetrachloroethene
Trichloroethene
Trichlorofluoromethane (Freon 11)
Toluene
Total Trihalomethanes
Xylene

Based on the presence of these compounds in groundwater, a conservative estimate is that the same compounds with the possible exception of some of the trihalomethanes may be present in subsurface soil.

Potential Onsite Hazards

The predominant potential onsite hazard anticipated by the presence of VOC's would be as a result of subsurface soil excavation. Should an area of the site that previously contained a seepage pit or subsurface structure be encountered during an excavation, the possibility exists that particulates or vapors could be inhaled or ingested and dermal adsorption could occur. Mitigation measures, such as detailed mapping of these areas, have taken place as part of this Work Plan and will serve as screening tools should excavations be planned in the future. JPL currently has policies in place to be used during soil mitigation activities. Should an excavation be planned, JPL site personnel will be notified of the potential compounds to be encountered and monitoring of the planned excavation will occur using field instruments.

At this time JPL does not extract groundwater underlying the site for site use, therefore there is no potential for VOC exposure of workers due to groundwater use. JPL obtains its water from the City of Pasadena which carefully monitors water quality.

Potential Offsite Hazards

The potential offsite hazards associated with VOCs present in subsurface soil and groundwater underlying JPL include:

- o Volatilization of VOCs during an on-site subsurface excavation and subsequent inhalation off-site,

- o Mobilization of particulates containing VOCs and subsequent inhalation, ingestion, or dermal exposure,

- o Surface runoff of soil containing VOCs into the Arroyo Seco sediments or water followed by dermal exposure or ingestion, and

- o Consumption of drinking water containing VOCs, dermal exposure, and inhalation of vapors extracted from offsite production wells.

The most likely potential offsite exposure hazard is from groundwater containing VOCs. This potential hazard has been dramatically reduced in the past 11 years since all groundwater production wells in the area are routinely monitored for VOCs and those containing VOCs above drinking water standards are identified. Those wells identified as having VOCs in excess of drinking water standards are no longer in operation or the extracted water is treated to remove the contaminants prior to blending into the drinking water supply.

Potential Hazards to Wildlife

The potential hazards to wildlife in the area of JPL are very limited given the predominantly urban location of the site. As discussed earlier, the only two release mechanisms of concern might be due to wind erosion of particulates or surface water runoff into the Arroyo Seco. Both of these mechanisms are thought to be very limited in nature if present at all.

Currently there is a proposal by the City of Pasadena Water and Power Department for a multi-use Project for the Devil's Gate Reservoir area. This area is immediately southeast of JPL and extends from the mouth of the Arroyo Seco Canyon south to the Devil's Gate Dam. The project is called the Devil's Gate Multi-Use Project (DGMUP) and is designed to capture and preserve the natural resources and water resources of the area for use by the regional community. Some of the activities associated with this project include: reservoir basin cleanout, reconfiguration of flood handling facilities above the dam, possible rehabilitation of Devil's Gate Dam, and establishment and enhancement of wildlife habitat. Depending on the results of the RI, there may or may not be any potential hazards to this wildlife habitat.

Data Gaps for Quantitative Endangerment Assessment

The following data gaps have been identified in the existing site characterization data base for a quantitative endangerment assessment to be completed:

- o Identification of the nature and extent of VOCs in groundwater underlying JPL and the surrounding area;
- o Characterization of VOC contaminants, their extent and locations in subsurface soil; and
- o Estimates of the migration rate of VOCs in subsurface soil toward groundwater and the rate of VOC dispersion in groundwater.

This information will serve as a basis to quantitatively assess the hazards presented by VOCs in soil and groundwater at JPL.

2.4 IDENTIFICATION OF POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

CERCLA as amended by SARA of 1986 requires the selection of remedial actions at Superfund hazardous waste sites that are protective of human health and the environment, cost-effective, and technologically and administratively feasible. Section 121 of CERCLA specifies that response action must be undertaken in compliance with applicable or relevant and appropriate requirements (ARARs) established in federal and state environmental laws.

The revised National Contingency Plan clearly states that compliance with ARARs is one of the requirements for remedial alternative selection. The revised National Contingency Plan incorporates new requirements that in addition to federal ARARs, remedial alternatives must address state environmental requirements that are more stringent than corresponding federal standards.

In the draft guidance document "CERCLA Compliance with Other Laws Manual" (EPA, 1988), several different types of requirements are identified with which CERCLA remedial actions must comply: (1) chemical-specific requirements; (2) location-specific requirements; and (3) action-specific requirements.

Because situations at different sites vary widely, EPA cannot categorically specify requirements that will be ARARs for every site. For example, ARARs are identified in connection with the characteristics of the particular site, the chemicals present at the site, and the remedial alternatives suggested by the circumstances of the site.

EPA has specified that the different ARARs that may apply to a site and its remediation should be identified and considered at several points in the remediation planning process, as delineated below:

- o During preliminary planning for the RI/FS, chemical- and location-specific ARARs may be identified.

- o During the site characterization phase of the RI when the baseline risk evaluation is conducted, the chemical-specific ARARs and location-specific ARARs are identified more comprehensively and used to help determine preliminary cleanup objectives.

2.4.1 <u>Chemical-Specific ARARs</u>

This section identifies a preliminary set of chemical-specific ARARs that may apply to remedial actions at JPL. Section 2.4.1.1 provides an overview of the role of chemical-specific ARARs in the FS process. Section 2.4.1.2 summarizes a preliminary list of chemical-specific ARARs for compounds present at JPL.

2.4.1.1 Chemical-Specific ARARs in the Feasibility Study Process

Chemical-specific ARARs assume major significance as each remedial alternative is evaluated with regard to its effectiveness in protecting human health and the environment. The screening and detailed analysis of remedial action alternatives during the FS must consider effectiveness, implementability, and cost.

The ability to protect human health and the environment is a primary requirement that CERCLA remedial actions must meet. A remedy is considered protective if it "adequately eliminates, reduces, or controls all current and potential risks posed through each [exposure] pathway [at] the site." In accomplishing this, a given remediation alternative must meet or exceed ARARs or other risk-based levels established through a risk evaluation when ARARs do not exist or are waived.

Chemical-specific ARARs serve two primary uses: (1) to identify requirements that must be met as a minimum by a selected remedial alternative (unless a waiver is obtained) and (2) to provide a basis for establishing appropriate cleanup levels. The public health risk evaluation of a given remedial alternative characterizes the actual risk of exposure of humans to the contaminants of concern.

The requirement that a remedial alternative meet chemical-specific ARARs does not ensure that the alternative is protective, and therefore acceptable. Additional criteria for evaluating acceptability include:

- o Evaluating the combined risk associated with the ARAR limits for all chemicals at a given site (assuming additivity of effect).

- o Establishing that ARARs do not exceed EPA reference doses for noncarcinogenic effects, and are sufficiently protective when various chemicals are present.

- o Determining whether environmental effects are adequately addressed by the ARARs.

- o Evaluating whether the chemical-specific ARARs adequately cover all significant pathways of human exposure identified in a baseline risk evaluation.

The EPA Superfund Public Health Evaluation Manual (EPA, 1986) provides guidance on evaluating exposure to chemicals and on establishing acceptable exposure levels when no chemical-specific ARARs exist.

2.4.1.2 Identification of Chemical-Specific ARARs for JPL

Table 2-6 is a preliminary list of federal and state chemical-specific ARARs for metals, inorganic compounds, and organic compounds present at JPL. The constituents listed in Table 2-6 have been identified based on those previously identified in the groundwater or soil. Provided in Table 2-6 is a listing of: (1) the EPA primary and secondary drinking water standards; (2) EPA drinking water maximum contaminant level goals; (3) Federal Ambient Water Quality Criteria for the protection of human health for consumption of aquatic organisms and water; (4) California State drinking water standards; (5) California and federal standards for hazardous waste; (6) California and federal air quality standards; and (7) EPA proposed action levels for corrective action for solid waste management units at hazardous waste management facilities. In addition to the potential ARARs presented on Table 2-6, the Los Angeles County Department of Public Works will allow a maximum of 100 ppm of total petroleum hydrocarbons in soil before the soil needs to be remediated.

The exposure pathway currently of most concern at JPL is through groundwater. The chemical-specific ARARs in groundwater of primary importance are the federal and California water quality criteria and standards. These are briefly discussed below.

Maximum contaminant levels (MCLs) are enforceable EPA standards and represent the allowable lifetime exposure to a contaminant in public drinking water supplies. The maximum contaminant levels are established taking into consideration potential health effects and incorporate a safety factor to provide adequate protection for sensitive subpopulations. In establishing maximum contaminant levels, EPA also considers the feasibility of attaining such a concentration given the best available technology, treatment techniques, and cost.

As part of the process for developing a final drinking water standard, maximum contaminant level goals are established at concentrations that are associated with no known or anticipated adverse health effects. Maximum contaminant levels are typically set at concentrations as close to maximum contaminant level goals as is feasible.

Federal ambient water quality criteria are guidelines developed by the EPA Office of Water Regulations and Standards for the protection of aquatic life and human health. Although these are not enforceable standards, they represent scientific data and guidance to be used by the states in developing water quality standards.

State environmental quality standards may be applicable or relevant and appropriate for evaluating remedial actions at waste sites. The availability of, and numerical values for, these standards may vary widely from state to state, and may be more restrictive than federal criteria and standards. The revised National Contingency Plan notes that state

POTENTIAL CHEMICAL-SPECIFIC ARARs FOR JPL

Constituent	Federal Drinking Water Regulations: Primary Drinking Water Standards [a] MCLs (ug/l)	Federal Drinking Water Regulations: Drinking Water Maximum Contaminant Level Goals [a] MCLGs (ug/l)	Federal Drinking Water Regulations: Secondary Drinking Water Standards [b] (ug/l)	Federal Ambient Water Quality Criteria: Human Health: Consumption of Water and Aquatic Organisms (ug/l)	Contaminant Levels for Contaminants in Drinking Water MCL (ug/l)	EPA Action Levels for Groundwater in Aquifers [i] (ug/l)	California Department of Health Services Drinking Water Standards: Recommended Drinking Water Action Levels (ug/l)	California Department of Health Services Drinking Water Standards: Proposed Maximum Contaminant Levels (ug/l)
ORGANIC CHEMICALS								
Carbon Tetrachloride	5	0		(0.4) [e]	0.5	0.3		
Chlorobenzene						700		
1,2-Dichloroethane	5	0			0.5			
1,1-Dichloroethene	7	7		(0.033)	6			
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)							1,200	1,200
Tetrachloroethene		0 [d]		(0.8)	5	0.7		
Trichloroethene	5	0		(2.7)	5			
Trichloroflouromethane (Freon 11)							150	150
Toluene		2000 [d]		14.3		10,000	100	
Total Trihalomethanes [c]	100				100			
Xylenes					1,750	70,000		
INORGANIC CHEMICALS								
Cyanide				200		700		
Nitrate (as N)	10,000							
Nitrate (as NO_2)					45,000			
METALS								
Antimony						10		
Barium	1,000	1,500 [d]			1,000			
Beryllium				(0.0037)		0.008		
Cadmium	10	5 [d]		10	10			
Chromium (Total)					50			
Cobalt								
Copper	1,000 [d]	1,300 [d]	1,000	1,000 [f]	1,000			
Lead	50	20		50	50			
Molybdenum								
Mercury	2	3		0.144	2			
Nickel				13.4		700		
Zinc	5,000 [d]		5,000	500 [f]	5,000			
Strontium								
Vanadium								

a Source: U.S. EPA Regulations, 40 CFR Part 141 (Federal Register).
b Source: U.S. EPA Regulations, 40 CFR Part 143 (Federal Register).
c Refers to sum concentration of Chloroform, Bromoform, Bromodichloromethane and Dibromochloromethane.
d Proposed MCL or MCLG.
e Numbers in parentheses are federal ambient water quality criteria for potential carcinogens corresponding to the 10^{-6} per year risk level.
f Ambient water quality criterion based on organoleptic properties, not toxicity.
g California Administrative Code Title 22.
h No numerical state ambient air quality guidelines are available. A permit is required by the South Coast Air Quality Management District if during any remediation total VOC emissions is >50 ppm.
i Source: U.S. EPA Proposed Rule, 40 CFR Parts 264, 265, 270 and 271 (Federal Register). Corrective Action for Solid Waste Management Units at Hazardous Waste Management Facilities.

POTENTIAL CHEMICAL-SPECIFIC ARARs FOR JPL (Continued)

	California Standards For Hazardous Wastes		Federal Standards for Hazardous Waste	Federal Air Quality Standards				California Air Quality Standards
Constituent	Total Threshold Limit Concentration (TTLC)(mg/kg)	Soluble Threshold Limit Concentration (STLC)(mg/l)	RCRA - Toxicity Leaching Characteristic Procedure (TCLP)(mg/l)	EPA Action Levels for Soil [i] (mg/kg)	National Ambient Air Quality Standards NAAQS (ug/m3)	National Emission Standards for Air Pollutants NESHAPS	EPA Action Levels for Air [i] (ug/m3)	
ORGANIC CHEMICALS								
Carbon Tetrachloride			0.5	5			0.03	See footnote [h]
Chlorobenzene			100	2,000			20	
1,2-Dichloroethane			0.5	8			0.04	
1,1-Dichloroethene			0.7	10			0.03	
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)								
Tetrachloroethene			0.7	10			1.0	
Trichloroethene	2,040	204	0.5	60				
Trichloroflouromethane (Freon 11)								
Toluene				20,000			7,000	
Total Trihalomethanes [c]								
Xylenes				200,000			1,000	
INORGANIC CHEMICALS								
Cyanide								
Nitrate (as N)								
Nitrate (as NO_2)								
METALS								
Antimony	500	15		30				
Barium	10,000	100	100					
Beryllium	75	0.75		0.2		10 (24 hr)	0.0004	
Cadmium	100	1	1	40			0.0006	
Chromium (Total)	2,500	560	5					
Cobalt	8,000	80						
Copper	2,500	25						
Lead	1,000	5	5		1.5 (3 mo. aver)			
Molybdenum	3,500	350						
Mercury	20	0.2	0.2			3,200 (24 hr)		
Nickel	2,000	20		2,000				
Zinc	5,000	250						
Strontium								
Vanadium	2,400	24						

a Source: U.S. EPA Regulations, 40 CFR Part 141 (Federal Register).
b Source: U.S. EPA Regulations, 40 CFR Part 143 (Federal Register).
c Refers to sum concentration of Chloroform, Bromoform, Bromodichloromethane and Dibromochloromethane.
d Proposed MCL or MCLG.
e Numbers in parentheses are federal ambient water quality criteria for potential carcinogens corresponding to the 10^{-6} per year risk level.
f Ambient water quality criterion based on organoleptic properties, not toxicity.
g California Administrative Code Title 22.
h No numerical state ambient air quality guidelines are available. A permit is required by the South Coast Air Quality Management District if during any remediation total VOC emissions is >50 ppm.
i Source: U.S. EPA Proposed Rule, 40 CFR Parts 264, 265, 270 and 271 (Federal Register). Corrective Action for Solid Waste Management Units at Hazardous Waste Management Facilities.

standards, requirements, criteria, or limitations are to be considered ARARs only if these have been formally promulgated and consistently applied. California's current drinking water standards and waste quality standards are at times more stringent than the federal standards, and in those instances, take precedence over the federal standards.

2.4.2 Location-Specific ARARs

A number of statutes have requirements related to activities occurring in particular locations. For instance, waste management activities in flood plains are restricted under RCRA and critical habitats of endangered or threatened species are protected under the Endangered Species Act. Location-specific ARARs are regulatory requirements or restrictions placed on activities in specific locations that must be met by a given remedial action. These location-specific ARARs are used in conjunction with chemical-specific and action-specific ARARs to ensure that remedial actions are protective of human health and the environment by meeting the requirements of all applicable or relevant and appropriate regulations.

Federal statutes and regulations were reviewed to identify potentially applicable location-specific regulatory requirements that may apply to remedial activities at JPL. Specific characteristics of JPL considered in this evaluation were its location near a flood plain, its location in a seismic region, and the presence of an endangered plant species in the Arroyo. Table 2-7 summarizes these selected location-specific ARARs. In addition to these location-specific regulatory requirements the State of California has a number of regulatory requirements that also must be considered as part of this evaluation. Many of these regulations are general in nature and do not fall within the criteria set for chemical- or location-specific ARARs. These regulations are summarized in Table 2-8.

After reviewing the regulatory requirements it was determined that the flood plain and endangered species ARARs are potentially applicable to JPL. The seismic hazard ARAR is not applicable to JPL because there is no evidence of Holocene fault displacement on JPL or within the entire Sierra Madre fault system east of the San Fernando Valley (Agbabian, 1977).

TABLE 2-7

SUMMARY OF SELECTED LOCATION-SPECIFIC ARRARs FOR JPL

Location-Specific ARAR	Regulation	Applicability
Flood Plains	40 CFR Part 270 40 CFR Part 264 40 CFR Part 6	• If within 100-year flood plain, a new facility must be able to withstand washout from a 100 year flood. • Action must be taken to avoid adverse effects, minimize potential harm and restore and preserve natural and beneficial values to flood plain.
Within 61 meters (200 ft.) of a fault displaced in Holocene time	40 CFR Part 264.18	• New treatment, storage, or disposal of hazardous waste prohibited.
Critical habitat upon which endangered species or threatened species depend	Endangered Species Act 50 CFR Part 200 50 CFR Part 402 30 CFR Parts 320-330 Fish and Wildlife Coordination Act	• Action to conserve endangered species or threatened species, including consultation with the Department of Interior.

TABLE 2-8

POTENTIAL CALIFORNIA ARARs FOR JPL

I. STATUTES AND REGULATIONS

Statute	Regulation	Applicability
Safe Drinking Water and Toxics Enforcement Act (Proposition 65) (Chapter 6.6)	26 CCR Suppl. 1	Lists California recognized carcinogenic and reproductive toxic chemicals; regulates discharge of chemicals into drinking water and quantitatively defines "significant risk" to health.
Hazardous Substance Account Act (Chapter 6.8)	22 CCR, Division 4, Chapter 30	Principal requirement governing State Superfund program; emergency response; victim's compensation.
Calderon (AB 3525 and 3374) Section 41805.5 also Sections 66796.53 and 66796.54 of the Government Code and Section 13273 of the Water Code	No regulations currently promulgated; SWAT guidelines promulgated by ARB, CRWQCB	Applies to the testing of active solid and hazardous waste disposal sites to assess the potential for existing future release of air and water contaminants.
California Safe Drinking Water Act, Health and Safety Code, Division 7, Section 4010 et seq.	22 CCR, Division 4, Chapter 15, Domestic Water Quality and Monitoring	Maximum Contaminant Levels (MCLs) for public water systems; Lab Certification.
Porter Cologne Water Quality Control Act, Water Code, Division 7, Section 13,000 et seq.	23 CCR, Chapter 3	Identification of general duties and authorities of State and Regional Water Boards.
	Subchapter 9	Waste discharge reports and requirements.
	Subchapter 9.1	Enforcement procedures and septic tank prohibition review by the water board.
	Subchapter 10	Licensing and regulation of use of oil spill cleanup agents.
	Subchapter 15	Discharges of waste to land.
	Subchapter 16	Underground tank regulation.
	Subchapter 20	Standards for removal of sewage from vessels.
Fish and Game Code, Division 6, Part 1, Chapter 2, Sections 5650 and 5651		Fish and wildlife, water pollution prohibition, correction of chronic water pollution.

TABLE 2-8 (Continued)

POTENTIAL CALIFORNIA ARARs FOR JPL

II. OTHER STANDARDS, REQUIREMENTS, CRITERIA AND LIMITATIONS Other Standards, Requirements, Criteria and Limitations	Applicability
All policies and procedures for hazardous waste and hazardous materials management and cleanup adopted by the Toxic Substances Control Division	
Department of Health Services Decision Tree	Development of site-specific cleanup levels evaluation of remedial action alternatives.
Department of Health Services Exposure Criteria o RMCLs, MCLs, and action levels for unregulated chemicals in drinking water o Applied action levels developed by the Toxic Substances Control Division o Other cleanup levels developed by the Toxic Substances Control Division on a site specific basis.	
Toxic air quality criteria policies or standards generated by the Department of Health Services or the Air Resources Board	Department of Health Services
Air Pollution Control District application-specific regulations	Air pollution control regulations identified on a district or basin-wide basis.
Water Quality Control plans of the State Water Resources Control Board and the Regional Water Quality Control Board	Water quality and basin plans
Other requirements of the State Water Resources Control Board and Regional Water Quality Control Boards	
All policies and procedures for water quality control adopted by the State Water Resources Control Board and the nine Regional Water Quality Control Boards	Includes "Non Degradation" policy.
Regional Water Quality Control Board site remediation guidance and criteria	
All county hazardous waste management plans	
Hazardous Waste Move Committee Memorandum of Understanding	Transportation of hazardous waste during cleanup.

The ground surface elevations at the JPL site are above the Arroyo Seco flood plain elevation of 1,075 feet (Ebasco 1989), but there is a potential for a 100-year flood to affect some of the lower parking lot areas of JPL next to the Arroyo.

The Nevin's Barberry, a plant, is a Federal Candidate 1 species and State Endangered species has been observed in the Arroyo Seco Canyon approximately one-half mile downstream from JPL. If a remedial alternative is required for JPL, and if the remedial alternative requires the use of the Arroyo in any way, this endangered species ARAR may be applicable to JPL.

2.4.3 Action-Specific ARARs

Action-specific ARARs are performance, design, or other action-specific requirements that apply as a result of a specific technology or activity, or that are limitations on certain actions involving hazardous waste. Action-specific ARARs are identified during the development of remedial alternatives in the Feasibility Study, which is outside the current scope of this work plan. Specific requirements are triggered by the particular remedial activities within each alternative. Below is a preliminary list of laws and regulations to be considered in a later effort to develop action-specific ARARs.

- Federal Clean Air Act
- South Coast Air Quality Management District's Rules and Regulations
- Federal Clean Water Act
- Toxic Substances Control Act
- California Administrative Code Title 23, Chapter 3, Subchapter 15
- RCRA Guidance Document Addressing the Remedial Technologies Selected
- California Site Mitigation Decision Tree Manual

2.5 DATA USE REQUIREMENTS AND DATA QUALITY OBJECTIVES

This section presents an evaluation and identification of the data needs required for completing the JPL Remedial Investigation. Data requirements and quality issues will focus the Remedial Investigation and provide a general preview of activities that should be conducted. A description of activities planned for the Remedial Investigation is provided in Section 3 of the Work Plan.

The general objectives of the Remedial Investigation/Feasibility Study include:

- o Characterization of potential VOC content in the soil at JPL and in the environment surrounding JPL due to past waste disposal activities.

- o Characterization of the nature and extent of VOCs in the groundwater at JPL.

- o Performance of a risk evaluation based on the characterization of site conditions, and existing and potential contaminant migration pathways.

- o Evaluation of available remedial technologies, and, if necessary, the recommendation of potential remedial alternatives for the site.

To fulfill these objectives, the Remedial Investigation/Feasibility Study will include activities designed to evaluate existing data, and to collect and analyze new data.

The following sections present a discussion of gaps in the existing soil and groundwater data from JPL that have been identified. The need to fill a given data gap and the degree to which it is filled will be prioritized to most efficiently meet the objectives of the Remedial Investigation/Feasibility Study and to fulfill pertinent regulatory obligations. Ultimately the Remedial Investigation/Feasibility Study will provide the information necessary to establish potential risks to human health and the environment and to select the most technically and cost effective remedial alternative for the site should it be warranted.

2.5.1 Data Quality Objectives

The development of Data Quality Objectives (DQOs) governing proposed sampling activities at JPL constitutes an integral part of the RI/FS program. The Office of Solid Waste and Emergency Response Directive 9355.0-7B states that "Data Quality Objectives are qualitative and quantitative statements specified to ensure that data of known and appropriate quality are obtained in support of remedial response activities and agency decisions." Data Quality Objectives are developed through an iterative process designed to establish the level and extent of sampling and analysis required to produce data adequate for the evaluation of remedial alternatives.

It is not always possible to identify data needs during the initial stages of a site investigation. Therefore, as more data are collected, the requirements for those data, and ultimately the appropriate Data Quality Objectives, will be refined to fulfill the objectives stated above. Specific Data Quality Objectives can be defined according to the following EPA levels of sophistication:

- Level I - Field screening. This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.

- Level II - Field analysis. This level is characterized by the use of portable analytical instruments which can be used on-site, or in mobile laboratories stationed near a site (close-support labs). Depending upon the types of contaminants, sample matrix and personnel skills, qualitative and quantitative data can be obtained.

- Level III - This level is used primarily in support of engineering studies using standard EPA approved procedures without the EPAs Contract Laboratory Program requirements for documentation.

- Level IV - This level is characterized by rigorous QA/QC protocols and documentation and provides qualitative and quantitative analytical data.

- Level V - Non-standard methods. Analyses which may require method modification and/or development.

Primarily Level III data will be collected for the JPL RI. These data will be used for site characterization, conducting risk evaluations, evaluating remedial alternatives, and engineering design. Some Level II data will also be collected; however, this data will be used only during interim field sampling activities, for health and safety purposes, or to establish the relative location or concentration of contaminants.

In addition, the following quality assurance objectives for analytical data will be identified according to the following criteria:

1. Precision: Precision represents the reproducibility of measurements under a given set of conditions. Precision is expressed in terms of standard deviation, Relative Standard Deviation (RSD), range, or relative range. The laboratory objective for precision should be to equal or exceed the precision demonstrated for like samples, and should be within the established control limits for the methods.

2. Accuracy: Accuracy is a measure of the bias or error in a sample program. Examples of bias include contamination and errors made in handling and analysis. Accuracy should be assessed by the use of known and unknown QC samples and matrix spikes. Accuracy should be measured by the percent bias or percent recovery. The laboratory objective for accuracy should be to equal or exceed the accuracy demonstrated for the analytical methods on like samples, and should be within the established control limits.

3. Representativeness: Representativeness is the degree to which the sample data accurately and precisely represent an environmental condition. Representativeness should be satisfied by making certain

that sampling locations are selected properly and a sufficient number of samples are collected. Representativeness is addressed by describing the rationale for each sampling.

4. Completeness: Completeness is the percent of measurements made which are judged to be valid. The completeness of the data reflects that all the required samples have been taken and requisite analyses performed to generate an adequate database to successfully complete the planned studies.

5. Comparability: Comparability expresses the confidence with which one data set can be compared with another. The sampling methods employed, the chain-of-custody methods responsible for the transfer of the sample, sample collection, preservation, and the analytical techniques implemented at the laboratories will be performed in a uniform manner.

6. Sufficient Quality: The samples must be large enough to provide a sufficient amount of site materials to conduct the analyses and treatability tests, as appropriate.

2.5.2 Data Requirements for VOC Source Characterization

There appear to be several deficiencies in the available data on the potential VOC source locations that have been reviewed to date. The program proposed may provide the additional data needed; however, the possibility exists that additional data may be required to pinpoint final source areas. In particular, design drawings showing proposed seepage pit locations have not been compared with as-built drawings or demolition plans when structures have been removed. Cross-checks between drawings have shown that seepage pits were not always installed at the proposed locations and thus this issue needs resolution.

Inconsistencies in verbal reports from active and retired JPL employees as to disposal practices and where dumping chemicals into sumps actually occurred need to be clarified for several suspect locations. Suggestions from JPL personnel interviewed that other retired key employees be interviewed for more exact information on "sump" locations; these key retirees have not been available for previous interviews. Most of the JPL personnel interviewed did not participate in site-walks to pin-point dumping locations but suggested that other certain individuals would be able to do so.

Several known seepage pits have been determined to lie along or just within the footprint of newly constructed buildings. The foundation and construction drawings for these new structures need to be reviewed to ascertain whether or not soil borings can be drilled at these locations. Also, sanitary sewer construction drawings have not been reviewed. It is possible that these drawings may show specific points along the pipe alignment where tie-ins from the septic systems connected into the new sewer lines.

Specific data needs for further source characterization are the following:

- o Review microfiche files for drawings with dimensional facilities to confirm measurements extrapolated from noted scales.

- o Research other categories of construction drawings in the microfiche files (e.g., demolition plans, buried utilities, grading plans, etc.).

- o Examine "hard-copy" drawing files for available data where microfiche are not on sewer system installations, storm drains, foundation and grading plans for newer buildings constructed at former building sites.

- o Re-interview key JPL personnel and have them participate in site walks to finalize boring locations.

- o Interview retired key JPL personnel, with associated site walk, that have additional knowledge of previous activities at specific locations during the 1950s.

2.5.3 Data Requirements for Groundwater Investigation

The major data requirements for the groundwater portion of the remedial investigation relate to water quality and groundwater flow direction. An attempt will be made to further identify the nature of VOCs in groundwater and the horizontal and vertical extent of these compounds. Water quality samples need to be collected routinely from existing monitoring wells to determine if changes in water quality occur with time or with pumping of the City of Pasadena water production wells. Water samples will be collected from the proposed monitoring wells to further assess the occurrence of VOCs in the groundwater. Analysis of chemical data from these water samples should aid in determining the extent of VOCs and may also aid in detecting any shift in the VOCs due to the recent start-up of pumping at the nearby Pasadena production wells.

Historic water quality and water level data, collected for the local production wells, indicate a change in the water quality with pumpage and time. Thus, it will be important to monitor both water levels and water quality throughout the RI.

Water level data from routine measurements in existing and proposed monitoring wells is required to determine the direction of groundwater flow, the effects of pumping from the Pasadena production wells, and the effects of artificial and natural recharge. The water level data will be used to construct a series of water level maps depicting the change in water table configuration created by the pumping wells and precipitation events with time. The drawdown maps will aid in verifying a numerical model which will be used to predict the long-term effects of pumpage, and the maps will also aid in placing the screened intervals in the proposed monitoring wells.

Hydraulic conductivity data will be used to estimate the rate and volume of groundwater flow at the JPL site and will be a driving factor in numerical modeling efforts. When hydraulic conductivity and water level data are input to a numerical model, the model may be used to simulate groundwater flow and the effects of pumping. To check the feasibilities of different types of remediation, should it become necessary, or to design a pumping system, estimates of the amount of groundwater which would have to be managed are required. Hydraulic conductivity data can be obtained from measurements in the deep multi-port wells, from production well data, and/or from an aquifer test. Hydraulic conductivities may vary by more than two or three orders of magnitude in non-stratified sediments due to the heterogeneity of the materials.

In addition to these requirements, the historic pumping rates and any water level measurements from the local production wells will be reviewed to aid in determining the potential aquifer drawdown due to long-term pumping. Future plans and schedules for pumping of the Pasadena wells need to be reviewed and incorporated into the verification of a groundwater flow model. Both historic and potential recharge from the Arroyo Seco Canyon and Arroyo Seco spreading grounds will have to be estimated and incorporated into the model.

A summary of data requirements for the groundwater investigation follows:

- Water quality samples from existing monitoring wells, analyzed by a state certified laboratory according to EPA guidelines;

- Water quality samples collected after installation of proposed monitoring wells;

- Historic water level and quality data from nearby production wells;

- Water level data from existing and proposed monitoring wells, measured to the nearest .01 ft;

- Hydraulic conductivities from deep MP wells, from previously conducted tests of production wells, and from an aquifer test, if additional data is required; and

- Historic and future pumping rates from local production wells.

2.6 PROJECT PLANNING (TASK 1)

Planning for the Remedial Investigation/Feasibility Study (RI/FS) consists of the preparation of this Work Plan, the site specific Health and Safety Plan (HASP), and the Community Relations Plan (CRP). The HASP and CRP will be completed and submitted at a later date prior to the start of field activities.

Contents of the HASP and CRP can be summarized as follows:

- o HASP: includes site information; a hazard evaluation; training requirements; monitoring procedures for site operations; safety considerations during site operations; and decontamination and disposal procedures.

- o CRP: documents community relations history; documents issues of community concern; and describes techniques needed to achieve objectives of program.

Procedures to be used during the RI/FS, including those to be used during detailed sampling and analysis, data management, field operations, and Quality Assurance/Quality Control (QA/QC), are described in detail in following sections.

Preliminary planning for the JPL RI/FS has included reviews of the Preliminary Assessment/Site Inspection Report (Ebasco 1988a, 1988b), the Expanded Site Inspection Report (Ebasco, 1990a), the Remedial Investigation/Feasibility Study Work Plan Scoping Report (Ebasco, 1990c), all reports on previous environmental investigations conducted, and of files of historical building plans currently being maintained at the facility.

2.7 AGREEMENTS

In early 1990, JPL entered into an agreement with the City of Pasadena to fund the construction and operation of a facility to treat groundwater containing VOCs for several production wells located in the Arroyo. To date there have been no other agreements with regulatory agencies or other parties to provide funds or studies to investigate or remediate contaminants found in groundwater underlying JPL.

2.8 COMMUNITY RELATIONS (TASK 2)

The JPL community relations program will be a site-specific and integral component of the overall RI/FS process. The JPL community relations effort will include activities to promote two-way communication between JPL and the local community. These activities will also ensure that the local community receives accurate and timely information about site investigation and clean-up efforts and that local concerns and needs are included in all project decision making. The overall goals of the JPL community relations program are as follows:

- o Inform the local community of planned or ongoing actions
- o Promote public comment on and input to technical decisions
- o Focus and resolve any conflict

JPL's community relations program will be designed and implemented by JPL staff members with technical support and review by Ebasco's Community Relations Coordinator (CRC). Initial activities in JPL's community relations program include:

- o Initial Briefing - conducted by Ebasco's CRC to familiarize JPL staff with the goals and requirements of a community relations program and begin planning for the development of JPL's community relations plan.
- o Coordination Meeting with EPA - conducted to establish an early working liaison with EPA's CRC for the JPL site and to ensure that JPL's community relations program conforms with the most current EPA policy and requirements.

- Community Relations Plan (CRP) - JPL staff, with Ebasco technical support, will conduct community interviews and develop a site-specific CRP for the JPL site. The draft CRP will be submitted to EPA for approval.

- Initial Fact Sheet - JPL will develop an initial fact sheet for distribution to persons interviewed for the CRP and local officials, business leaders, and interested community members. The fact sheet will describe the JPL site history, current environmental problems, and the goals of the RI/FS. The initial fact sheet will also describe opportunities for public involvement and may include a mail-back coupon for addition to the JPL site mailing list.

The JPL community relations program will be designed in accordance with all applicable EPA guidelines, as expressed in its Community Relations in Superfund: A Handbook, Interim Version, June 1988.

3.0 REMEDIAL INVESTIGATION

This section describes the proposed Remedial Investigation (RI) activities for groundwater and potential VOC source areas at JPL. Specific discussions addressing the RI strategy, proposed field activities, sample analysis and validation, data evaluation, baseline risk evaluation, supplemental field work, and the RI report format are presented here. Given the current lack of understanding of the nature and extent of VOCs in groundwater and soil at the site, the possibility exists that the proposed activities presented in this RI plan may need to be supplemented with additional activities at a later date.

3.1 PROPOSED FIELD INVESTIGATIONS (TASK 3)

The field work proposed for the RI consists of two main components: 1) groundwater VOC assessment, and 2) VOC source assessment. To investigate these two components, the proposed work has been segregated into sequential RI activities. This phased approach has been selected so that newly acquired data obtained during the RI can be incorporated into on-going activities. The focus and extent of many of the RI activities are contingent upon results of previously completed activities. A flowchart is useful for summarizing the work sequence and is presented in Figure 3-1.

The VOC source assessment component of the RI focuses on defining the locations and the extent to which each location may have or is presently contributing to the VOC content of the groundwater. Because of surficial changes, such as building demolition and construction, erosion, excavation, etc. in areas where waste disposal may have occurred in the past, and uncertainties about precise disposal locations, a number of sampling methods may be necessary to achieve the program goals. The type and sequence of these methods will be designed to allow time to evaluate the results and re-evaluate subsequent plans. Details of this sampling program are discussed in Section 3.2.

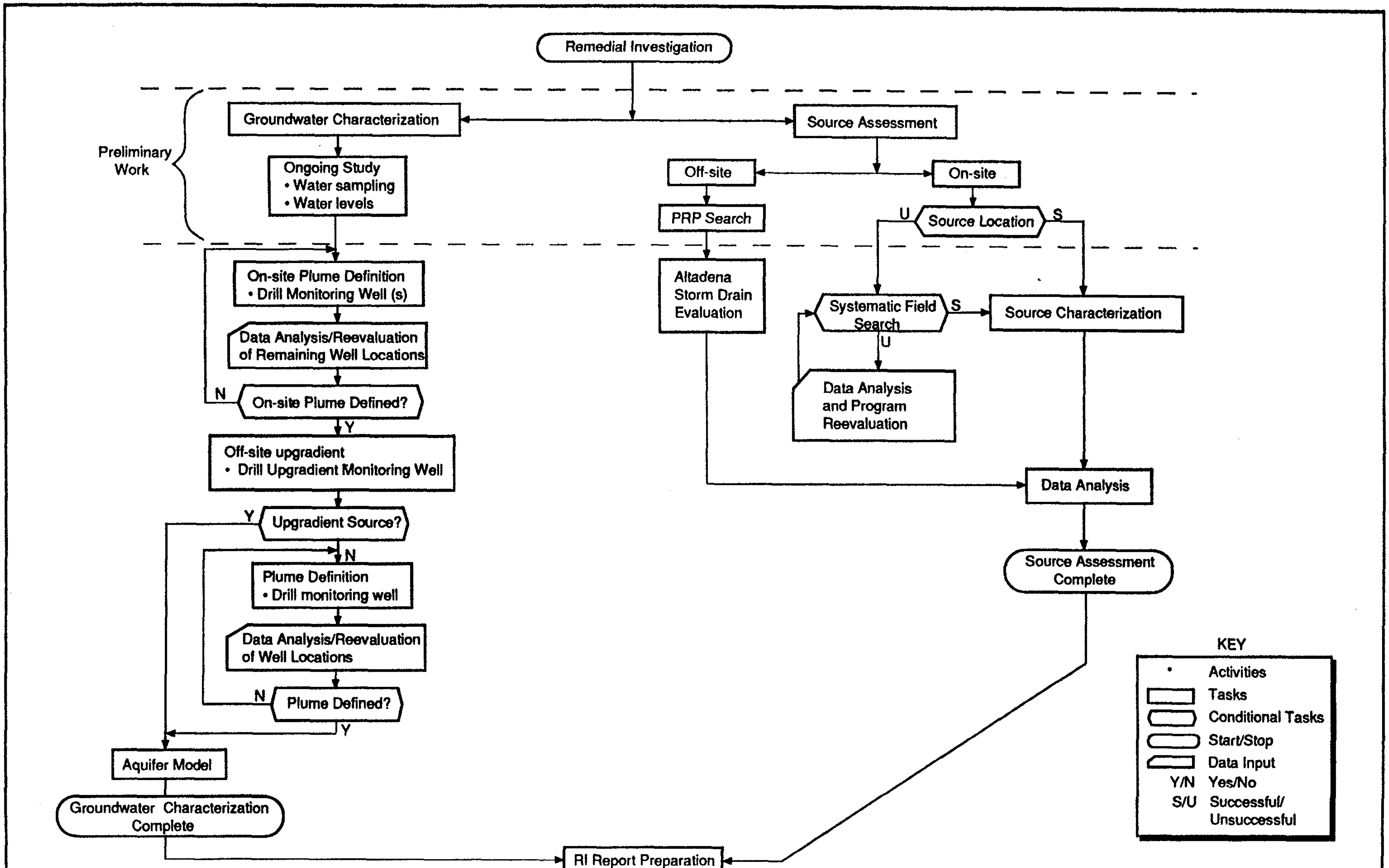


Figure 3-1

Flowchart Summarizing RI Investigative Activities for JPL.

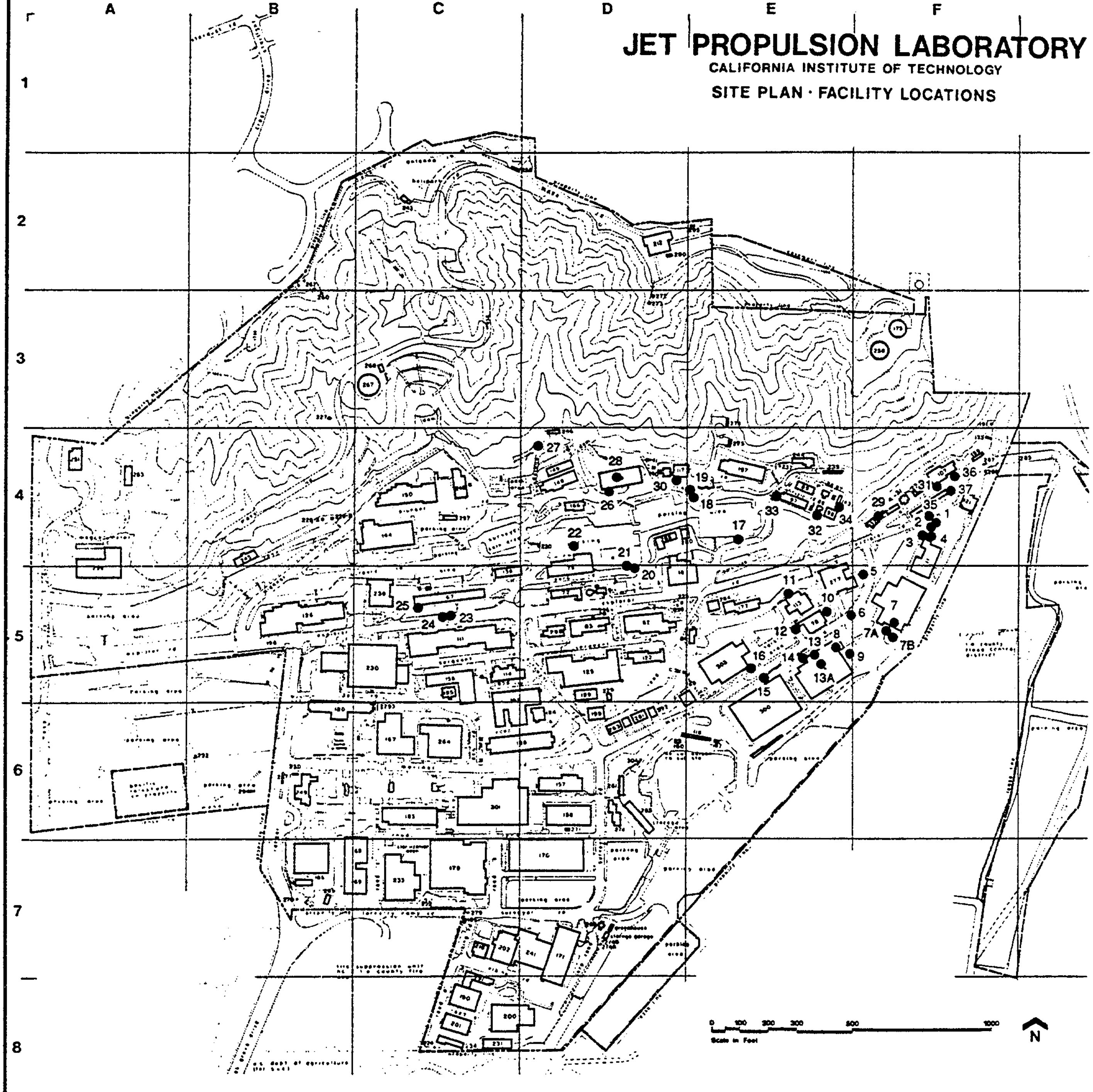
The groundwater characterization component of the RI focuses on determining where contaminants may occur, the vertical and horizontal extent of contaminants, if detected, and the concentrations of contaminants. To increase the effectiveness of the well-drilling program, a sequence of drilling will be designed to allow time to evaluate analytical results and, thus, reevaluate the location of the next well or set of wells to be drilled.

3.2 SOURCE IDENTIFICATION PROGRAM

During the 1940s and 1950s, cesspools were used to dispose of liquid and solid sanitary wastes from lavatories, drains and sinks at many JPL buildings. These cesspools were designed to allow liquid wastes to seep into the surrounding soil; hence, the present-day terminology for these structures is "seepage pits," and this term is used in this work plan. Information gathered during interviews with active and retired JPL personnel indicated that many of these seepage pits may have received various quantities of chemicals used at the facility. Although the seepage pits were abandoned in the late 1950's to early 1960's when a sewer system was installed, a number of these seepage pits may be the original source of contaminants currently detected in the groundwater at JPL.

3.2.1 Seepage Pits

Following the review of JPL facility records and interviews with current and former JPL employees, 40 seepage pits (including three dry wells) have been identified at the approximate locations shown in Figure 3-2. Historical aerial photographs did not have enough resolution to aid in locating these seepage pits. Listed in Table 3-1 are the building-identification numbers that each corresponding seepage pit (or dry well) served. Based on interviews with JPL personnel, other alleged seepage pits may be located adjacent to Buidlings 87 and 88 in the solid propellant preparation area. However, evidence of these seepage pits was not found in the construction drawings for the buildings and was not visible on the ground surface during site inspections.



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12 ● Seepage Pit or Dry Well Location and Number

Figure 3-2

LOCATIONS OF KNOWN SEEPAGE PITS AND DRY WELLS

TABLE 3-1

BUILDING NUMBERS AND THEIR CORRESPONDING SEEPAGE PITS

Seepage Pit No.	Building No.	Building Name
37 (DW)	2	*
1, 2	3	*
1, 2	4	*
3, 4	11	Electrical and Plumbing Shops and Stores
31	12(?)	Test Cell
9	13	Offices, Lab and Shop
1, 2	17	*
1, 2	22	Thermocouple Lab
29	32	Test Cell #32 Liquid
15	34	Shop-Test Cell #33 Liquid
9	44	Credit Union
14	46	Shop-Test Cell #42 Liquid
18, 19	52	*(Partial record file only)
17	55	Solid Mixing Lab
16	59	Paint Shop
20, 21	63	Compressor and Shop Building
8 (DW), 13, 13A,	65	Materials Lab
23, 24, 25	67	Engineering and Labs
5	68	*
5	71	Mechanics Stores
12	74	Chemistry Test Cell
26, 28	77	Corrosion Lab
10	78	Hydraulics Lab
22	80	12" and 21" Wind Tunnel
35	81	Shop, Office, and Stores Building
32	86	Oxidizer Grinding
18, 19	90	Shop-Test Cell #51 Solid
33	97	Development Laboratory and Offices
34	98	Preparation Shop (Solid Propellant)
11	101	Transportation Offices and Shop
7, 7A, 7B	103	Fabrication Shop and Inspection
11	104	First Aid and Fire Dept.
36	107	Test Cells A and B
30	117	Solid and Liquid Propellant Laboratory
27 (DW)	246	Soils Test Lab
6	*	*

*Unknown, no historical building records at JPL.

DW - Dry well.

Source: Historic facility maps and construction drawings in JPL's microfiche files.

An unusual pit existed north of former Building 77 (Pit 28, Figure 3-2). The original purpose of this pit was to neutralize fluorine exhausts from experimental fluorine propellants by lining the bottom of the pit with crushed limestone. Drawings prepared in 1947 indicate that the pit was square in plan view and identified as an "acid pit." The same structure is shown to be circular and identified as a dilution chamber on drawings dated in 1948. Other drawings in 1958 called the structure a cesspool. However, this pit is currently located under Building 299 and was reportedly backfilled with sand prior to the construction of Building 299. The changing history of this pit is typical for many of JPL's earlier facilities and is representative of the site's evolution and development.

Based on the results from reviewing construction drawings and facility maps, histories of the buildings' usage, and verbal reports from JPL personnel, only two of the 40 known seepage pits and dry wells can be eliminated as potential contamination sources. These are seepage pit Nos. 22 and 27 (dry well). Nine of the remaining 38 seepage pit or dry well locations are not accessible by drilling equipment because of terrain or obstructions.

This work plan proposes that 20 primary seepage-pit locations be drilled and sampled based on the rationale summarized in Table 3-2. An additional two soil borings will be drilled and sampled at other primary locations based on reported dumping of solvents or physical evidence of contaminants at these locations. These 22 primary boring locations are shown in Figure 3-3. Seven secondary drilling locations are also proposed, but further research on existing building foundations is required before it is possible to drill borings at these locations.

The borings will be drilled and sampled to an approximate depth of 60 feet below grade with a percussion hammer drill rig using a dual-wall drive pipe and reverse air circulation. Soil samples will be collected for laboratory analysis at 10-foot intervals beginning at a depth of 10 feet. The final sampled intervals of each boring may be altered depending on visual and field instrument measurements.

TABLE 3-2

BORING LOCATION RATIONALE

Boring Reference No.	Seepage Pit No.	Associated Building No.	Influencing Factors
PRIMARY LOCATIONS:			
1	1	3, 4, 17, 22	Pit located in area having oldest use-history on JPL site; recent discovery of solvents and other contaminants in nearby seepage pit that was uncovered during ongoing construction work.
2	3	11	Same as above.
3	5	68, 71, 127	Original uses of Bldgs. 68 and 127 are not known; Building 71 was used as "mechanics stores." Buildings located near old solid propellant bunkers and may have been used to store solvents used in mixing and developing propellants.
4	6	Unknown	Drilling and sampling proposed as implications are similar to those for seepage pit Nos. 1, 3 and 5.
5	7B	103	Building houses machine shop, fabrication shop, and metal pickling room; solvents used for cleaning and degreasing; alleged dumping of liquids in "drain hole" near southeast corner of building.
6	12	74 & 78	Chemistry test cell (liquid propellants) and a hydraulics laboratory shared common seepage pit; solvents used for cleaning; disposal of chemicals reported to have occurred by pouring into drains.
7	15	34	Shop building associated with old test cell buildings (Pit "F") and liquid testing facility; spilled solvents reportedly small, but did occur on regular basis over several years.
8	17	55	Solid propellant mixing facility; solvents used to clean mixing hardware and disposed by pouring into sumps before connecting to sanitary sewer system.
9 & 10	18 & 19	90	Shop for test cell No. 51 (solid propellant testing in Pit "X"); large test motors and hardware soaked in tubs of solvents (included carbon tetrachloride and acetone) that were not recycled and allegedly dumped into sumps on west side of Building 90 or at east end of solid propellant preparation area (east of Building 88).
11	20 & 21	63	Compressors and maintenance shop; solvents routinely used for parts cleaning. Soils beneath both seepage pits could be sampled with single angle boring.
12	26	77	Structure housed experimental chemistry lab and fluorine propellant test cell with an acid pit constructed similar to dry well; numerous chemicals reportedly disposed by dumping into available sumps near building. Seepage pit is upgradient from monitoring well MW-7.
13	29	32	Test cell used for liquid propellant testing since mid-1950's; solid propellants used during late 1940s. Seepage pit located near area where ongoing construction work disclosed solvent contamination in storm-drain catch basin and previously unknown seepage pit.
14	30	117	Building housed former solid propellant test cell where solvents used to clean rocket motors and hardware; solvents reportedly not recycled and disposed of by dumping into nearby drains and sumps.
15	33	97	Development laboratory for solid propellant chemistry experimentation; solvents used to clean laboratory hardware; all sink drains led to seepage pit; a sump or dry well at west end of building reportedly used for solvent disposal.

TABLE 3-2 (Continued)

BORING LOCATION RATIONALE

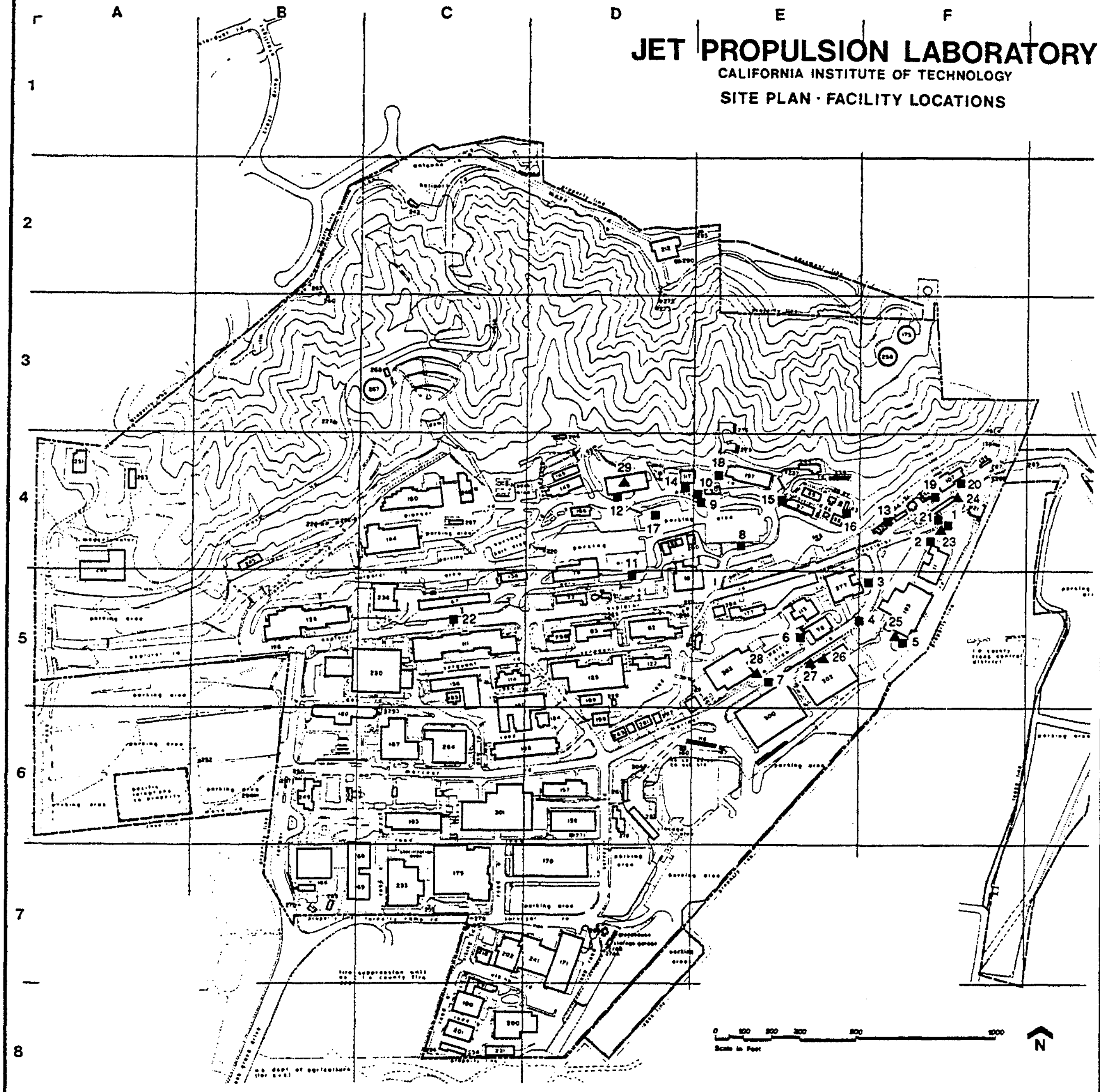
Boring Reference No.	Seepage Pit No.	Associated Building No.	Influencing Factors
PRIMARY LOCATIONS: (Continued)			
16	34	98	Seepage pit at east end of solid propellant preparation area (Bldgs. 86, 87, 88, 89, and 98); pit reportedly used for disposal of carbon tetrachloride, methyl ethyl ketone, trichloroethene, cyclohexanone (?), and other chemicals after sewer system installed.
17	NA	None	Old storage area for propellant materials and solvents (including carbon tetrachloride, trichloroethene, alcohols, and freon); spills reportedly occurred. Location upgradient from monitoring well MW-7.
18	NA	197	1000-gallon tank (possible leakage) located at west end of building; propellant grindings and solvents reportedly dumped into tank at frequent intervals.
19	31	12, 23, 112	Storm drain catch basins removed during ongoing construction were contaminated with carbon tetrachloride, acetone, chloroform, trichloroethene, and mercury; sump tanks (leakages reported), dilution chambers, and seepage pits, associated with test cells and shops, existed along north side of Jato Road).
20	36	107, 112	Both buildings contained propellant test cells; solid propellants may have been used during early history of buildings, along with solvents associated with solid propellant clean up. Building 107 later converted to plasma flow research laboratory. Implications are associated with same rationale for boring reference No. 19.
21	35	81	Building housed work shops, storage rooms, and offices. Seepage pit located in same area where solvents and other chemicals discovered in soil during ongoing construction. (See rationale for boring reference Nos. 19 and 20.)
22	23, 24	67	Building's history is diverse. Although mainly an office building, several small laboratories (biology, kinetics, low-level radioactive, and spectroscopy) were located within the structure over a several-year period—possibly before connections made to sanitary sewer system.
SECONDARY LOCATIONS:			
23	2	3, 4, 17, 22	Connected downstream to seepage pit No. 1. Drilling and sampling at this location is dependent on laboratory analysis results on samples from boring drilled at seepage pit No. 1.
24	37(DW)	2	Dry well for drain from building has unknown use, but implications are same as those for boring reference Nos. 1, 3, 5, and 19.
25	7A	103	Seepage pit located upstream from 7B and located beneath electric substation. Could be drilled and sampled with angle boring. (See rationale for boring reference No. 5.)
26	13	65	Materials laboratory; may have housed machinery and metals cleaned with solvents; also housed chemistry laboratory; bottom of pit in building for universal testing machine drained to dry well.
27	14	46	Shop for liquid propellant test cell; implications are same as those for boring reference Nos. 6 and 7.
28	16	59	Building housed old paint shop; high potential for paint solvents having been disposed in seepage pit serving facility.

TABLE 3-2 (Continued)

BORING LOCATION RATIONALE

Boring Reference No.	Seepage Pit No.	Associated Building No.	Influencing Factors
SECONDARY LOCATIONS: (Continued)			
29	28	77	"Acid Pit" for Bldg. 77; now under Bldg. 299 with access for small HSA rig inside. Drilling and sampling dependent on laboratory analysis results on samples from borings drilled at reference locations Nos. 11 and 16.
SEEPAGE PITS ELIMINATED:			
NA	22	80	Wind tunnel building; no history of solvent or chemical usage.
NA	27(DW)	246	Dry well from sink at former soils test laboratory; no history of solvent or chemical usage.

NA - Not applicable.
DW - Dry well.



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4 ■ Primary Location and Reference Number

26 ▲ Secondary Location and Reference Number

Figure 3-3

PROPOSED SOIL BORING LOCATIONS

Attempts will be made to locate the soil borings within or as close to the seepage pits as possible. The coordinates of each known seepage pit and dry well have been calculated to match the grid system used at JPL. Because of inaccuracies inherent with transferring dimensions from microfiche enlargements at differing scales, the calculated coordinates are believed to have a margin of error ranging from ±2 to ±5 feet. The grid points for the accessible seepage pits will be marked in the field by surveying from established reference points (bench marks) on the site. Where appropriate for the specific grid point, ground-penetrating radar may be used in an attempt to more accurately define the subsurface location of the seepage pit. Alternatively, a backhoe may be used to excavate shallow trenches to locate the tops of the seepage pits prior to drilling the soil borings.

3.2.1.1 Soil Sampling Procedures

Soil samples will be collected at 10-foot intervals from each soil boring beginning at a depth of 10 feet. The final sampled intervals of each boring may be altered depending on visual and field instrument measurements. Soil samples will be collected with a split spoon sampler following the procedure described below:

- o Drill to the desired sampling depth using the reverse circulation air percussion hammer rig with dual wall drive pipe. The dual wall drive pipe will not be driven below the prescribed sampling depth.

- o A 2½-inch (I.D.) by 18-inch split spoon sampler will be lowered on a cable down through the middle of the dual wall drive pipe to the sampling depth. The sampler will be equipped with a 140-lb hammer than can fall 30 inches. The sampler will be loaded with three stainless steel or brass sample tubes, each measuring 2½ inches (O.D.) by 6 inches.

- o The sampler will then be driven into the soil beneath the drill bit with the sliding hammer. The number of blows required to drive the sampler each 6 inches into the soil will be recorded on the boring log form. A sample of the soil boring log form is presented in

Figure 3-4. The first 6 inches of penetration is considered a seating drive. The number of blows required for the second and third 6 inches of penetration is termed the penetration resistance. If the sampler is driven less than 18 inches, the boring logs shall state the number of blows and the fraction of the 18 inches penetrated.

- The sampler will then be brought out of the boring. Both ends and one-half of the split spoon sampler will be removed to retrieve the three sample tubes. One sample tube will be used for sample description purposes, one for laboratory analysis, and one for quality control purposes as required. The ends of the soil sample to be sent for laboratory analysis will be trimmed, covered with teflon sheets, and capped with plastic end caps. The sample will then be labeled, put in a zip-lock bag, and placed in a cooler full of ice for transport to the laboratory. The sample to be used for the lithologic description will be monitored for the presence of organic vapors with a flame ionization detector (FID). This will be done for data acquisition purposes as well as for health and safety purposes. The value measured with the FID will be recorded on the boring log.

Lithologic descriptions of the soil cuttings and soil samples will be recorded on the field boring logs (Figure 3-4) and will include the following:

- Physical characterization and grain size distribution of the sample
- Stratigraphic boundaries
- Presence of any inferred visible contaminants
- Color changes
- Moisture content
- Thickness of individual units
- Samples taken
- Odor
- Any other conditions encountered during drilling (i.e., changes in drilling rate, etc.)

EBASCO ENVIRONMENTAL

SOIL BORING NO.

PROJECT *JPL RI/FS*

BORING LOCATION

GEOLOGIST

DRILLING CO.

DRILLING METHOD

BIT SIZE, HAMMER WT, DROP

GROUND ELEVATION (ft)

TOTAL DEPTH DRILLED (ft)

DEPTH TO WATER (ft)

DATE (start/finish)

DEPTH (ft)	BORING COMPLETION	SAMPLE NO.	SAMPLES	BLOWS/6-inch	OVA (ppm)	LEL (%)	ODOR	MOISTURE	DENSITY	LITHOLOGY	LITHOLOGIC DESCRIPTION AND NOTES Example: Sediment type, Color, Grain Size, Sorting, Grain Shape, Structure, Accessories, Inferred Visible Contamination

FIGURE 3-4
Boring Log Form

In addition to completing the boring log form, a bound field notebook will be used to record all other pertinent information relating to all aspects of field work.

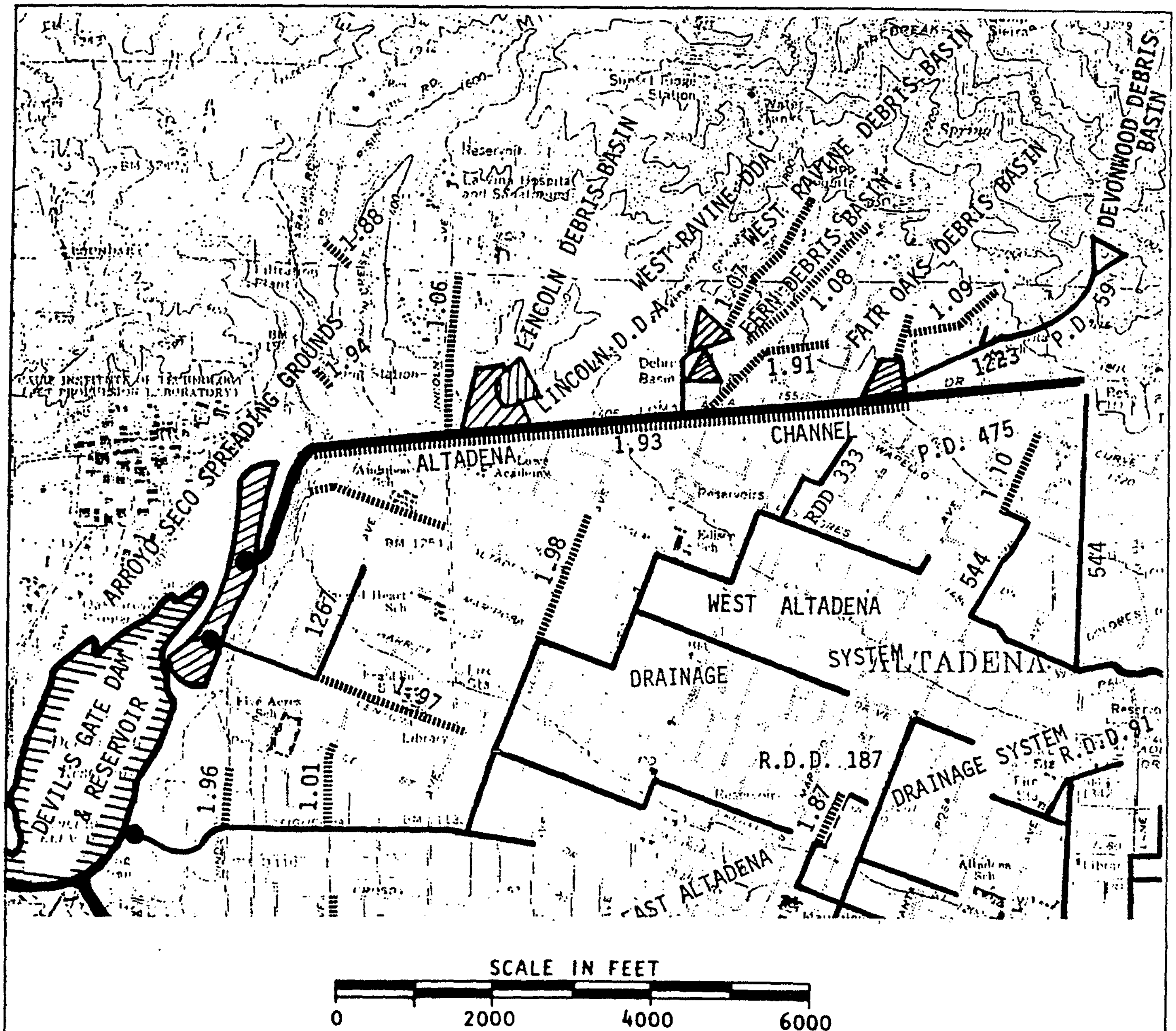
After all of the samples have been collected from a particular boring, that boring will be backfilled with a bentonite grout to the ground surface and abandoned. The dual wall drive pipe will act as a tremie pipe during the backfilling procedure and will be removed as the bentonite grout is being added. Any asphalt or concrete damaged during drilling operations will be repaired to its original condition.

All potentially contaminated materials generated during the field investigation, including soil cuttings, will be collected and stored. During drilling activities, the soil cuttings will be placed and stored in rolloff bins. The analytical results from the soil samples collected will be used to determine the proper method of disposal. Soils determined to be non-hazardous may be used onsite as fill materials in an approved location. If some soils are determined to be contaminated, the appropriate DOT manifesting procedures will be followed and the material handled properly.

Equipment decontamination procedures for all subsurface soil drilling and sampling equipment are presented in Section 3.4. Labeling, packaging, and chain-of-custody procedures are also presented in Section 3.4.

3.2.2 Altadena Storm Drain Assessment

Surface water runoff in west Altadena is collected by a system of channels and storm drains which empty into the Arroyo Seco (Figure 3-5). Three of these drains discharge into the Arroyo to the east, south, and southeast of JPL. To investigate these storm drains as potential sources of groundwater contamination in the Arroyo Seco area, soil samples will be collected from a boring located at the discharge point of each of the three Arroyo drain outlets (Figure 3-5). In addition, if weather and conditions permit, a water runoff sample will be collected from each drain outlet.



LEGEND

▬▬▬	EXISTING L.A.C.D.P.W. CHANNELS & STORM DRAINS
------	EXISTING SYSTEMS MAINTAINED BY OTHERS
▬ ▬ ▬	STORM DRAINS PROPOSED
▮▮▮▮▮	DRAINAGE NEED
//////	EXISTING DAMS, DEBRIS BASINS & SPREADING GROUNDS
3.21	3 IDENTIFIES QUADRANGLE QUADRANT .21 REFERS TO REFERENCE NUMBER
●	PROPOSED BORING LOCATION

N

SOURCE:
COUNTY OF LOS ANGELES DEPT. OF PUBLIC WORKS
PLAN FOR FLOOD CONTROL AND WATER CONSERVATION,
PASADENA QUADRANGLE, 1985

FIGURE 3-5

PROPOSED BORING LOCATIONS ADJACENT TO THE WEST ALTADENA FLOOD CONTROL DRAINAGE SYSTEM

The northernmost of the three storm drain outlets (Figure 3-5) empties into the spreading grounds located in the Arroyo Seco. The middle of the three storm drain outlets (Figure 3-5) apparently also empties into the spreading grounds in the Arroyo Seco. The exact location of the discharge outlet for this storm drain will be found either using maps from the Los Angeles Department of Public Works or other means before the soil boring will be drilled. The southernmost of the three storm drain outlets (Figure 3-5) empties into a ditch in the Arroyo Seco. It appears a drill rig can be driven to locations adjacent to each of the drain outlets or channels coming from each outlet. A soil boring will be drilled as close to the mouth of each outlet as accessability will allow with a percussion hammer drilling rig down to a depth of 80 feet. If there is inferred soil contamination in any soil boring at 80 feet, drilling and sampling will continue as necessary to adequately characterize the soil. The rig will utilize 9-inch or 11-inch outside diameter dual wall drive pipe and reverse air circulation. Soil samples will be collected every 10 feet from the ground surface down to 40 feet, and every 20 feet after that down to the total depth of the boring. If contaminants are detected in the soil samples collected from these three borings, additional soil borings will be proposed to characterize the extent of contamination.

As the boreholes are being drilled and as the samples are being obtained, a flame ionization detector (FID) will be used to determine the presence of volatile organics. This will be done for both safety reasons and for data collection. The FID will be used to determine the level of respiratory protection required, and it also will be used as the hole is being drilled to determine if there are changes in volatile organics emanating from the hole.

After each sampling depth is reached with the dual wall drive pipe, a California split spoon sampler will be lowered on a cable down through the center of the drive pipe and used to collect a relatively undisturbed soil sample from immediately below the drill bit. The sampler will hold 2-½ by 6-inch brass or stainless steel sample tubes which will be removed after each sample is collected.

Equipment decontamination procedures for all subsurface soil drilling and sampling equipment are presented in Section 3.4. Sample labeling, packaging, and chain-of-custody procedures are also presented in Section 3.4.

All drill cuttings from the three borings will be placed in separate roll-off bins and stored for later disposal. The method of disposal will be dependent upon the laboratory test results conducted on the soil samples.

After all of the samples are collected from each borehole, each borehole will be backfilled to the ground surface with a bentonite grout or with neat cement. The dual wall drive pipe will act as a tremie pipe during the backfilling procedure and will be pulled out of the hole while the grout or cement is being put into the hole to keep the walls of the boring from collapsing and bridging off the borehole.

An Ebasco geologist will direct the drilling and the collection of samples and will prepare the soil boring logs. An example of the soil boring form to be used is presented as Figure 3-4.

3.3 GROUNDWATER INVESTIGATION PROGRAM

The groundwater investigation program is designed to detect the nature and extent of VOCs which may exist in groundwater beneath and downgradient from possible source areas at JPL. Source areas have been and will be researched concurrently with the groundwater investigation. Initial results of both investigations will determine the further placement of monitoring wells to detect these VOCs. A previous study detected VOCs in groundwater samples from two wells on-site but have not verified the nature and extent of VOCs (Ebasco, 1990a).

The potential source areas of greatest concern are believed to be in the northeast section of the JPL property, generally where well EMW-7 is located. Installation of monitoring wells to identify the areal extent of VOCs will begin in that section of the site. Additional wells may be sited and installed based on the direction of groundwater flow, and results from analysis of soil samples from soil borings and from water quality sampling.

VOCs were detected in water samples from well EMW-5, located in the southern portion of the site (Figure 3-6). One additional shallow well will be installed upgradient from well EMW-5, to verify the existence of VOCs and/or to better determine their origin. It is not certain whether the samples from well EMW-5 were indicative of onsite VOCs or may have been more representative of an up-gradient contribution. It has been documented that groundwater production wells apparently up-gradient to JPL owned by the Valley Water Co. contain VOCs.

Following the installation of monitoring wells, and depending on the results of water quality data, an aquifer test may be conducted. The data from an aquifer test, along with water level and water quality data, would be used in the hydrogeologic evaluation.

3.3.1 Installation of Wells

Two wells (EMW-8 and EMW-9) will be installed southeast of well EMW-7 to be completed 40 feet below the water table (Figure 3-6). These wells are designed primarily to allow water quality sampling to detect low concentrations of VOCs, and will also allow monitoring of water levels as they are affected through time by pumpage of the Pasadena production wells. The production wells are approximately 2000-4000 feet southeast of well EMW-7, and the closest pumping well is approximately 1500 feet southeast from the sites of the two proposed monitoring wells. The production wells are currently pumping and affecting the local groundwater flow gradient. The placement of screens in the proposed monitoring wells will depend on the long-term projected drawdown created by the pumping wells. The drawdown is currently being monitored by regular water level measurements in existing monitoring wells. Since the production wells have only been pumping a few months following a long-term shutdown, and there have been some adjustments or shutdowns of the wells recently, the total drawdown has not yet been determined.

JPL
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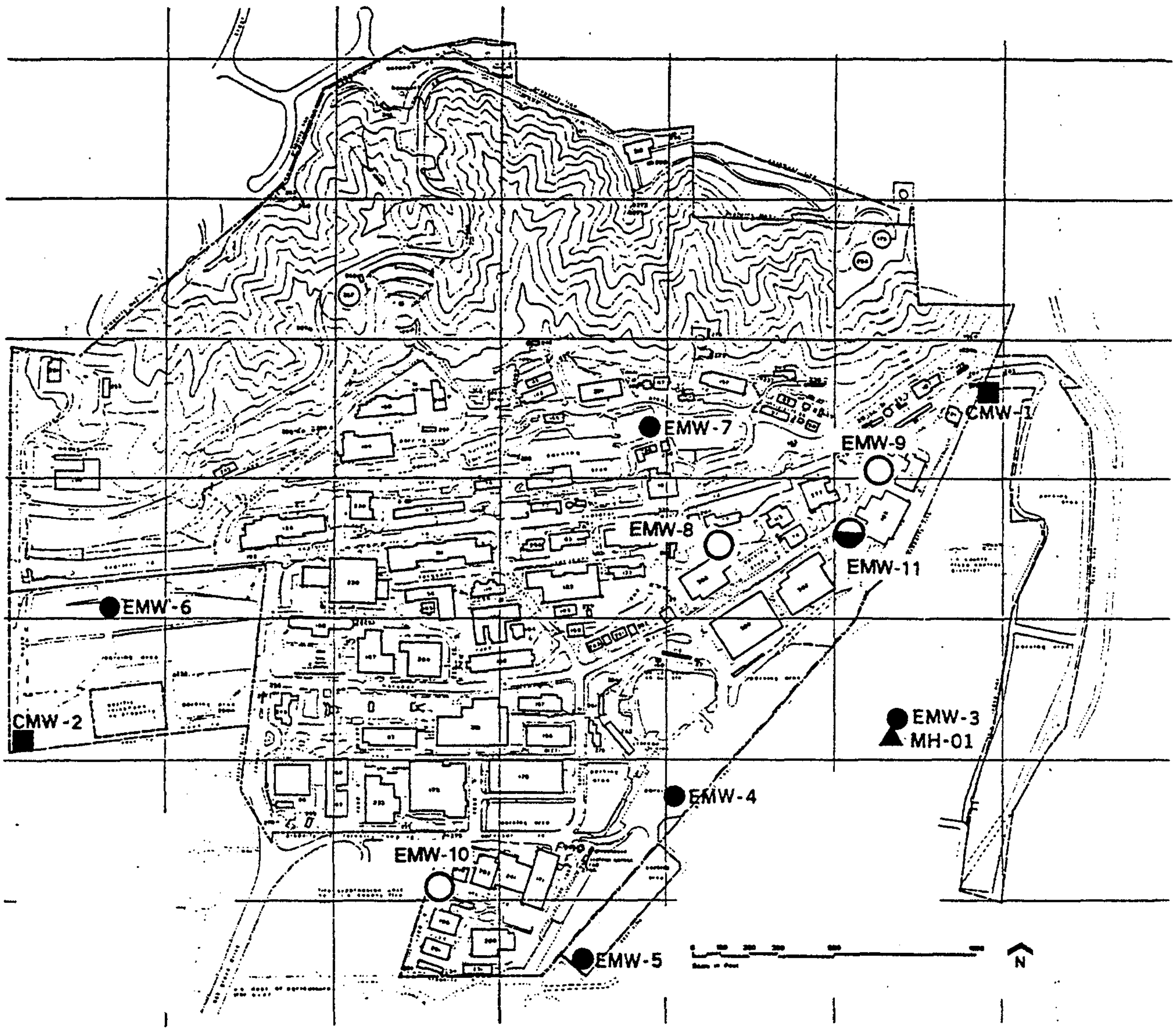
California Institute of Technology



Phase I: Site characterization.

○ Proposed shallow monitoring wells
◒ Proposed deep monitoring wells

Legend:

● Installed during the ESI investigation

■ Installed by the Army Corps of Engineers in 1989.

▲ Installed by Geotechnical Consultants, Inc. in 1982.

FIGURE 3-6
Locations of Proposed Groundwater Monitoring Wells, JPL, Phase I

Should VOCs be detected in these two wells, then one additional well (EMW-11) is proposed to help define the vertical extent of the VOCs. This well would have multiple screened intervals which would be separated by packers to prevent cross-contamination similar to the existing wells EMW-3 and EMW-4. Water quality data from wells EMW-3, EMW-4, and the proposed monitoring wells will be evaluated along with pumpage from the Pasadena production wells to determine the need for additional monitoring wells.

Depending on the results of chemical analyses of water samples from proposed wells EMW-8, EMW-9, and EMW-11, and on the results of soil samples from the proposed soil borings, another set of two shallow wells may be located further southeast from well EMW-11. These wells may be shallow water table wells and may be completed to depths of 30-40 feet or 50-60 feet below the water table (Figure 3-7). These proposed wells will help bracket the possible VOC contaminants. If they do not provide enough water quality information to verify or rule out the existence of the boundaries of the VOCs, then additional wells may be required, including one more deep well (EMW-14) to further define the vertical extent of VOCs (Figure 3-7).

3.3.1.1 Well Drilling and Construction

Two types of monitoring wells will be drilled and constructed during the JPL RI. Wells similar to those proposed have been installed previously, in the spring of 1990, and are described in the Expanded Site Inspection Report (May 1990a). Shallow wells will be used to measure the elevation of the water table and to sample water quality in the upper portion of this aquifer. Deep wells with multiple, non-connected, screened intervals will be used to establish the vertical extent of VOC's in the groundwater.

Following drilling and construction of both shallow and deep wells, the elevations and locations of the new monitoring wells will be surveyed. A licensed land surveying company will conduct the survey using benchmarks previously established at JPL, and will provide field notes with a summary of results.

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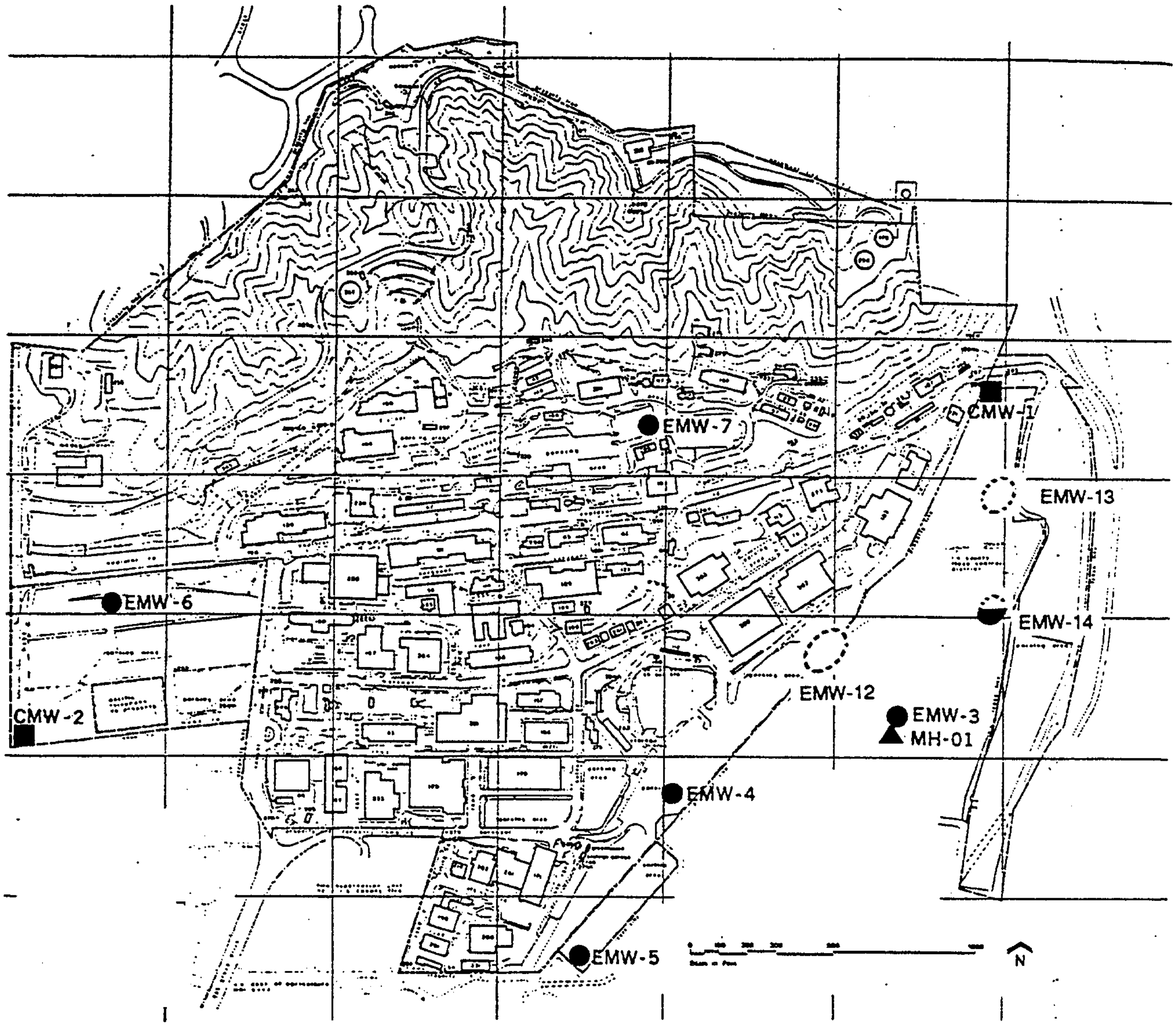


Phase II: Site characterization .

Proposed shallow monitoring wells

Proposed deep monitoring wells

Exact location depends
on Findings of Phase I drilling

Legend:

Installed during the ESI investigation

Installed by the Army Corps of Engineers in 1989.

Installed by Geotechnical Consultants, Inc. in 1982.

FIGURE 3-7
Locations of Proposed Groundwater Monitoring Wells, JPL, Phase II

Shallow Wells

Shallow monitoring wells will be drilled using a percussion hammer rig with a dual-wall drive pipe and reversed air circulation. The drive pipe will be an 11-inch outer diameter and 9-inch inner diameter dual wall tube. Drill cuttings will be circulated to a roll off bin, and checked for organic vapors with an OVA after, approximately, each ten feet of drilling. Samples of drill cuttings will be collected from just below ground surface and after every 50 feet of drilling.

Immediately after the drill cuttings are circulated out of the hole they will be placed in 500 ml glass jars, labeled, and placed in a cooler with ice. A chain-of-custody form will be completed and the samples sent to a state certified analytical laboratory. After the holes are drilled, the individual samples of cuttings from each well will be composited and the composite analyzed to determine the proper method of disposal for the cuttings. The composites will be analyzed for volatile and semi-volatile organics (EPA Methods 8240 and 8270), California Administrative Code Title 22 metals (EPA Methods 6010/7000) and total petroleum hydrocarbons (EPA Method 418.1).

If analysis of the cuttings indicates they contain constituents in concentrations deemed to be hazardous, they will be properly disposed of offsite by JPL personnel.

The shallow wells will have 50 feet of screen, with approximately 10 feet above the saturated zone of the water table and 40 feet below. The purpose of this design is to allow for the sampling of contaminants at the water table surface, and dissolved-phase contaminants below the water table, and to obtain groundwater elevation information. The screen has been designed to this length because of the large fluctuation in water table elevations observed in other wells at the site due to pumping of the production wells.

The shallow monitoring wells will be installed according to the following general procedures:

- o Well depths will be set by the rig geologist based on the location of the water table at the particular boring;

- o After each well is drilled, a geophysical contractor will be subcontracted to run a gamma ray/neutron log in each well. For the log to be run the dual-wall drive pipe used to drill the well will be filled with clean water. The logging will be completed and all tools removed from the boring.

- o Clean, uncontaminated water will be used during drilling, logging and construction of the wells, and will be purchased and delivered to the site from an off-site supplier. The water will be sampled after delivery and analyzed for volatile organics (EPA 624), metal cations (Title 22 metals and Sr), cyanide (EPA 9010) and cations/anions for mass balance.

- o Fifty (50) feet of 4-inch diameter, stainless-steel wire-wrap well screen with .010-inch slots and a bottom cap will be lowered into each hole through the middle of the dual-wall drive pipe. Slot size is based on sieve analysis completed during previous investigations. The well screen will be followed by 20 feet of 4-inch diameter stainless steel blank casing and then by 4-1/2 inch diameter schedule-80 PVC flush threaded blank casing. Before each joint of casing is run into the boring it will be steam cleaned and measured. Centralizers will not be used for the shallow well as the inner tube of the dual wall casing will act to centralize the casing. Figure 3-8 shows the typical design of the shallow monitoring wells.

- o The dual wall drive pipe will be used as a tremie pipe while placing the backfill materials.

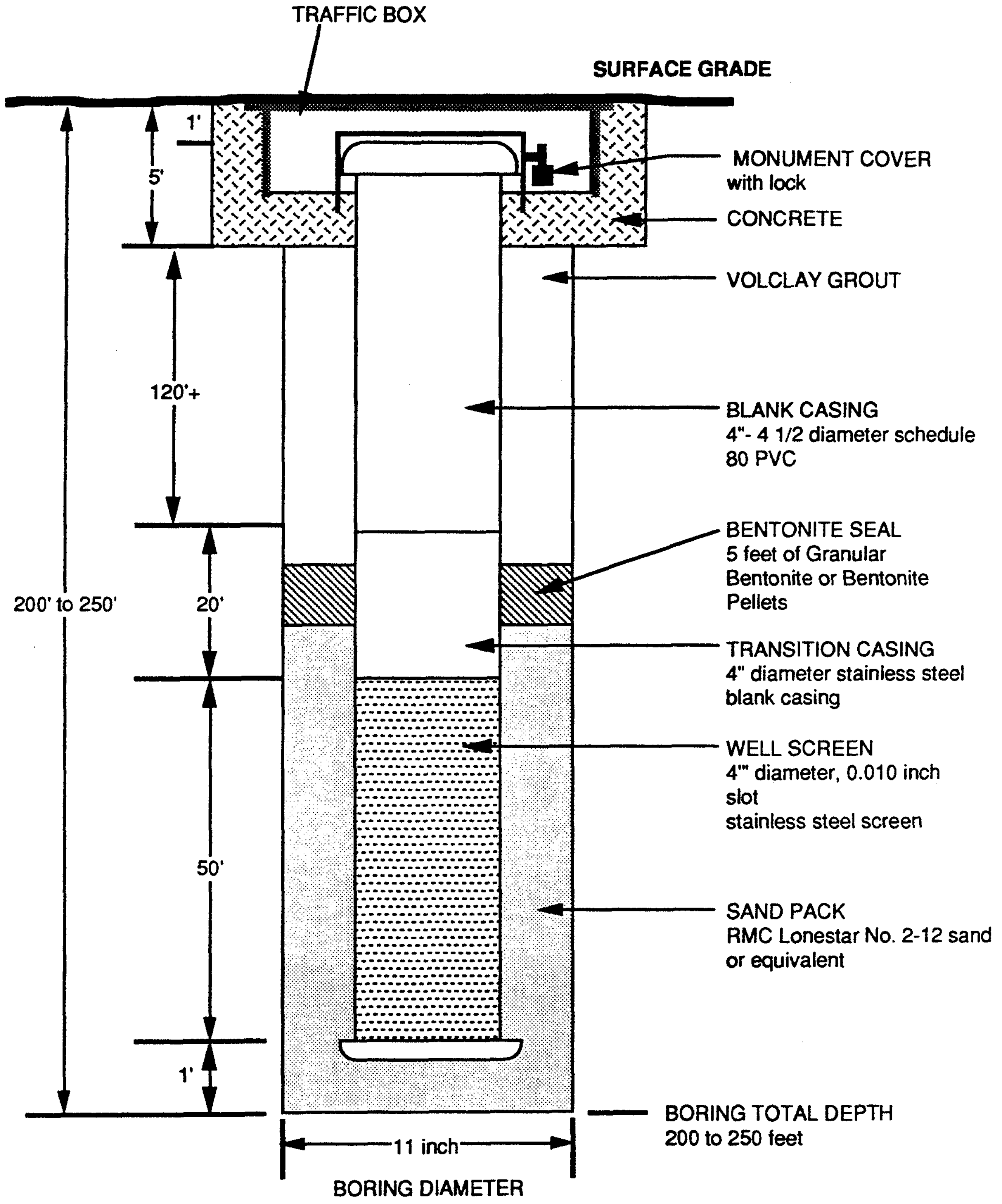


FIGURE 3-8

DESIGN OF TYPICAL SHALLOW GROUNDWATER MONITORING WELL

E#23-J

- The dual wall drive pipe will be removed from the borehole one section at a time to keep the formation from caving as backfill materials are added.

- The annular space between the well screen and the boring wall will be backfilled from the bottom of the well to at least 10 feet above the top of the well screen with clean, kiln dried, Lonestar sand. A five foot section of bentonite seal will be placed on the sand, and the remaining annular space will be backfilled with volclay grout. The backfilling procedure will be carefully monitored with frequent depth measurements.

- A locking monument cover and a steel and concrete traffic box will be installed at each well. Ready mix concrete will be used to secure the monument cover and traffic box in place; and

- The traffic box at each well will be set just above grade in such a way as to direct surface runoff away from the casing.

After the well is installed, it will be developed to remove all fine materials from the water and stabilize the well pack material. Development of the shallow wells will be accomplished by initially swabbing the screened interval with a rubber-disc swab tool and bailing the lowermost portion of each well to remove as much sediment as possible, after which pumping with a submersible purge pump will begin. Initially, the pump intake will be lowered to the bottom of the well and pumping will commence for approximately 10 minutes to remove any heavy, sediment-laden fluid that has settled there. Then the pump intake will be raised and pumping will commence at increasingly higher levels up to the last 5 feet below the water table. Pumping will begin and continue until physical and chemical parameters of the discharge water have stabilized and at least 5 well volumes of water have been produced. Occasionally, the pump will be turned off to surge the formation. All discharge water will be stored in a proper container until the appropriate method of disposal can be determined.

Deep Multi-Port Wells

The deep multi-port (MP) wells have been designed to sample the aquifer at several depths using a single borehole. Two similar systems were installed at Wells EMW-3 and EMW-4 using a multi-port casing system manufactured by Westbay Instruments Ltd. (Ebasco, 1990a). During this RI, additional deep wells will be constructed in the same manner (Figure 3-9).

At this time, one to two deep wells, will be completed in this manner to provide adequate vertical definition of water quality near the area of EMW-7. Clean, uncontaminated water will be used during drilling, stabilization, logging, and construction of the deep MP wells. The clean water will be delivered to the site from an off-site supplier. A sample of the water will be obtained after each delivery for analysis of volatile organics (EPA 624), metal cations (Title 22 metals and Sr), cyanide (EPA 9010), and cation/anion balance.

Mud rotary drilling techniques will be used to drill the deep MP wells. A pilot hole will be drilled to approximately 20 feet and 16-inch diameter low carbon steel conductor casing will be cemented in place. Drilling will continue with 12-1/4 inch bit to a total depth of 600 - 800 feet depending on the location of basement rock. During drilling, pure bentonite drilling mud and hydrocarbon free pipe dope will be used. The drilling fluid will be circulated from the hole to a screened shaker and through a de-sander to separate the drill cuttings from the drilling mud.

Drill cuttings will be collected in a roll off bin and will be checked for organic vapors with an flame ionization detector (FID) after each 10 feet of drilling. Samples of cuttings will be collected for chemical analysis when drilling is below the conductor casing and after every 100 feet of drilling. The individual samples of the cuttings will be sent to a state-certified laboratory. The laboratory will make a composite sample from all discrete samples collected to be analyzed for volatile and semi-volatile organics (EPA Methods 8240 and 8270), Title 22 metals plus strontium, cyanide, and total petroleum hydrocarbons (EPA Method 418.1). The laboratory results will be used to determine the best disposal method for the cuttings.

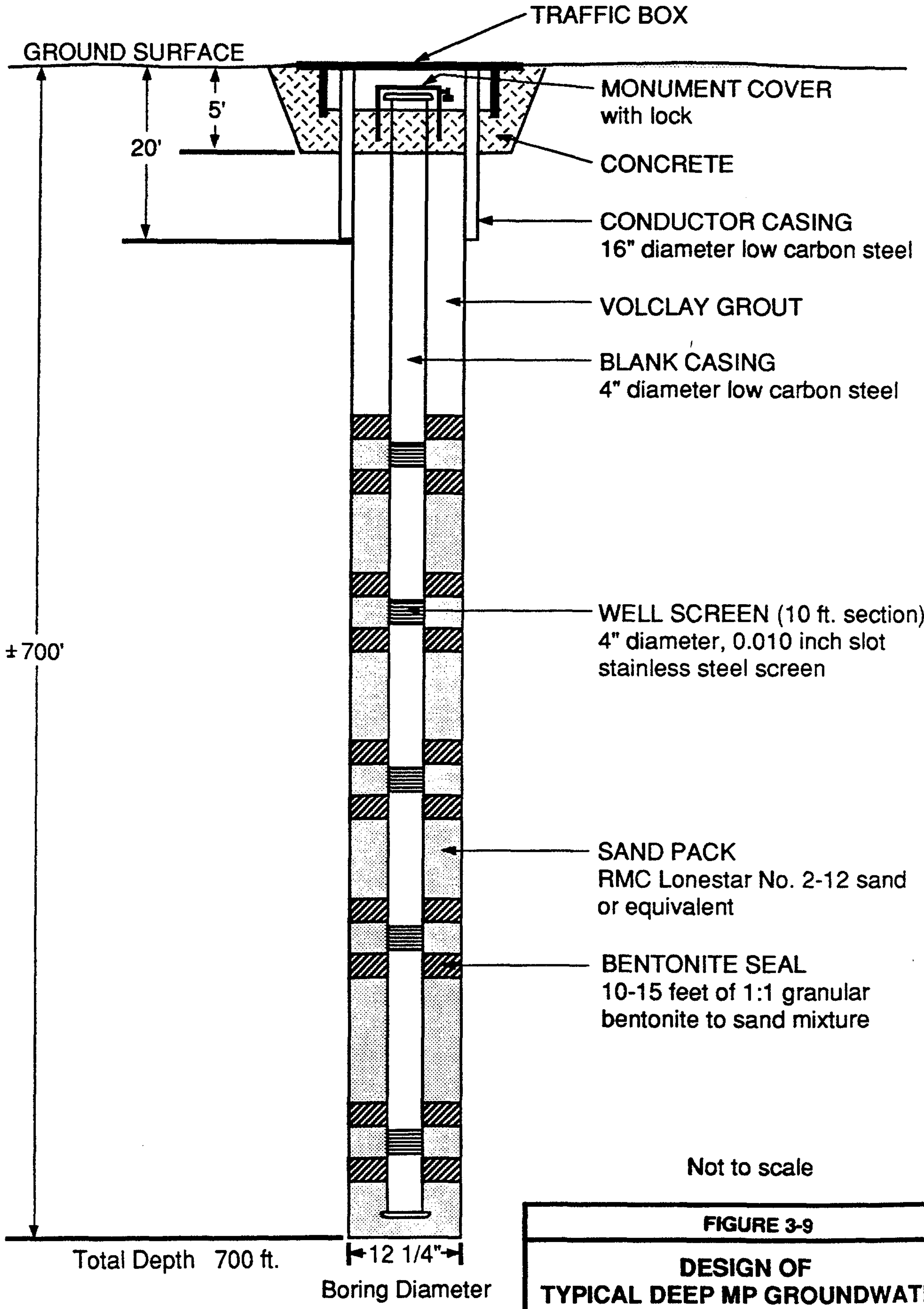


FIGURE 3-9

DESIGN OF TYPICAL DEEP MP GROUNDWATER MONITORING WELL

After drilling is completed, wireline geophysical logs will be run by a subcontractor. An electric log and gamma-guard log will be run in each borehole to aid in determining screen placement design. Other logs may be run to better define the borehole, if they become necessary.

The well casing, 4-inch diameter low carbon blank, and 4-inch diameter 304 stainless steel wire-wrap screen, will be run into the boring after the components have been steam cleaned and measured. The slot size of the well screen will be 0.010-inch based on previous well installations at this site. Some sections of the blank casing will be cut to specified lengths to place the screen at the depths determined after review of the geophysical logs. Centralizers will be welded onto the casing above the bottom cap and within 1 to 4 feet of the bottom of each well screen.

After the casing is landed, the bentonite seals and sand packs will be tremied into place. A grout pump will be used to circulate drilling fluid out of the hole and pump backfill materials into the boring. The backfill materials will consist of sand, a bentonite sealing mixture of sand and bentonite, and finally volclay grout. Next to the screened intervals and between bentonite seals, a clean, kiln-dried, #2/12 Lonestar sand will be used. Where a bentonite seal is required, a 1 to 1 mixture of pure bentonite granules and the same Lonestar sand will be placed in the boring. The backfilling process will be carefully monitored by frequent depth measurements with a weighted depth meter. The remainder of the backfill will consist of approximately 100 feet of volclay grout. After the grout has set, a locking monument cover and traffic box will be cemented in place.

The wells will be developed within 24 hours after installation by bailing and pumping/surging with a submersible pump. Development will continue from the uppermost to the lowest screened interval, using rubber packers inflated with compressed nitrogen comprising an isolated air-lift system. Development will continue until physical and chemical properties of the water have stabilized and until 3 to 5 well volumes per screened interval have been removed.

After initial development, the multi-port (MP) casing system will be installed. The MP system will consist of various casing components which will be permanently installed in the well. The casing components include blank 1½-inch diameter schedule 80 PVC casing, regular PVC couplings that connect various casing components together, PVC measurement port couplings that allow pressure measurements and water samples to be collected, PVC pumping port couplings that allow well purging or hydraulic conductivity testing of the aquifer, and nitrile rubber inflatable packers that seal the annulus between monitoring or screened zones.

Before the MP system is installed in each deep well, the components will be laid out in accordance with a casing installation log. This installation log is used to accurately place the packers and measurement ports at the correct levels. The MP casing string will be assembled by lowering the casing segments into the 4-inch steel casing by hand and attaching each successive segment to the adjacent coupling one at a time. Each joint will be pressure tested before it is run into the hole to verify the integrity of the system during installation. To pressure test each joint of casing, a probe with 2 small packers will be lowered into the casing so that these packers are located on each side of the joint. The packers will be inflated and water injected under pressure into the casing opposite the joint. If the joint does not leak, it will be lowered into the well.

Each MP casing component will be scrubbed with TSP prior to arriving at the site. Once the MP casing has been placed in each well, the packers will be inflated. The packers are inflated with water, one at a time beginning with the bottom most packer, through a packer inflation tool. Figure 3-10 shows a typical MP system installation.

After installation of the MP casing several QA/QC checks will be performed. These checks will include an initial pressure profile to confirm the operation of the measurement ports, and observation of head differences across the packers to confirm the packers have sealed the annulus. Further development of the well will be accomplished at each screened interval by opening the pumping port valve at that interval and purging water using compressed nitrogen. A 1-inch OD PVC pipe will be lowered to just below the

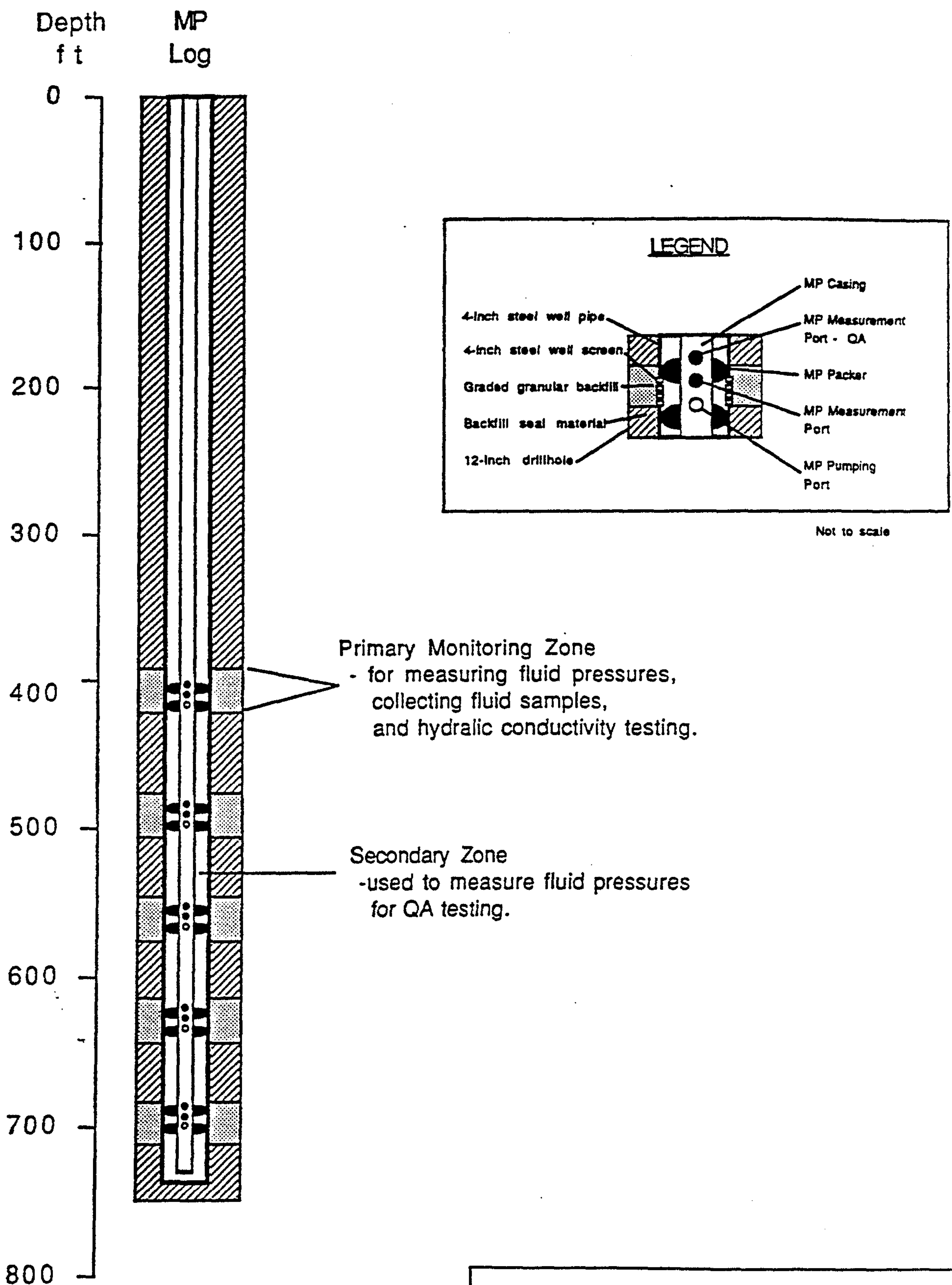


FIGURE 3-10

A Typical MP System Installation with 5 Monitoring Zones Completed Inside 4-inch Steel Well Pipe

pumping port valve and 1/4-inch plastic tubing will be lowered through the eductor pipe to just above the pumping port valve. Compressed nitrogen will be used to force water up the eductor pipe and will be shut-off occasionally to allow the water to drop and surge the formation.

3.3.2 Shallow Well Sampling

Immediately after development of the shallow wells, water level measurements will be recorded and sampling will begin. Samples will be collected with 3 feet long, 750 ml capacity stainless steel (single check valve) or teflon (double check valve) bailers, and/or with a small diameter low-flow submersible pump (<100 ml/minute). The bailers and pumps will be decontaminated before use by thoroughly washing with Alconox brand detergent and rinsing with de-ionized water.

At the beginning and after completion of sampling, pH, conductivity, and temperature parameters will be measured and compared to the final development parameters to check representativeness of samples.

3.3.3 Deep Well Sampling

Sampling at each deep well will begin after Westbay development at each well is completed. Samples from each screened interval will be obtained using a Westbay Sampler Probe with a total capacity of approximately one liter. The sampler probe consists of a series of four 250 ml stainless steel collection tubes linked together with flexible, plastic lined hoses. The uppermost collection tube is linked to an electrically activated valve opening assembly. The entire apparatus is suspended and lowered down the MP casing on coaxial cable. Prior to sampling each screened interval, the sampler probe and collection tubes will be disassembled and washed with Alconox brand detergent and rinsed with de-ionized water. The sampler probe will be lowered to several feet below the measurement port coupling adjacent to the screen of interest, and held there while an initial water level measurement is taken.

The sampler probe will then be raised and seated in the measurement port coupling of the screen being sampled. The measurement port coupling sample valve will be opened remotely from the surface allowing the formation fluid to fill the sample collection tubes. The sample valve will then be closed and a second water level measurement will be recorded. Comparison of the pre- and post-sampling water levels will provide a check of whether the sampling had proceeded properly; a significant difference between the two measurements will indicate that the sampler probe was not properly seated in the measurement port coupling and that the collection tubes might contain water from inside the MP casing. When this occurs, the water sample will be discarded and the collection tubes will be decontaminated before proceeding.

At each screened interval, pH, temperature, and conductivity will be measured at the beginning and end of the sampling run. These values will be compared to the final development parameters to ensure that the water samples collected are representative. From each screen, several sample bottles will be filled, requiring several sampling trips. At the surface, the water sample will be emptied from the collection tubes through a valve at the lower end. The same assortment of analyses, bottles, and vials will be used for the deep and shallow well sampling (Section 3.5.2).

3.3.4 Aquifer Testing

An aquifer test may be used to better determine hydraulic conductivity in the area containing VOCs depending on the location of the highest concentrations. If the VOCs are located southeast of well EMW-7, the test may not be necessary, as there may be sufficient data on hydraulic conductivity from previously installed multiple-screen wells or from the proposed multiple-screen wells, along with data from pumping of the Pasadena production wells.

All methods of determining hydraulic conductivity will provide only order-of-magnitude results because sediments in this area are poorly sorted and poorly consolidated. An aquifer test may not provide any better data than the data which is currently available from the installation of the multi-screen, multi-port wells and/or data that can be obtained from the Pasadena wells. The main factor in determining whether additional data on hydraulic conductivity is necessary will be the location and extent of VOCs. If VOCs are identified in areas away from well EMW-7 and EMW-3, then an aquifer test may be necessary.

3.3.5 Hydrogeologic Evaluation

The hydrogeologic evaluation will initially consist of reviewing the water quality, water level and hydraulic conductivity data. Water level and water quality data collected from existing and proposed wells will be used to determine the extent of on-site VOCs at the JPL facilities. If VOCs are identified, data concerning hydraulic conductivities, along with water level data and pumping rates from local production wells, may be used to create a model of the JPL site. The model would simulate both steady-state and current pumping conditions and would be used to predict the long-term effects of pumping on local groundwater flow. The modeling efforts should aid in determining how groundwater flow is and can be controlled by pumping and can provide a basis for any remedial design efforts, should they be needed.

The model selected for the JPL site is foreseen as a modular 2- or 3-dimensional finite difference groundwater flow model. The initial input to this model would be existing water level data collected prior to startup of production pumping and hydraulic conductivity data to describe steady-state hydrologic conditions. The model would then calculate water-level elevations (heads) through time or several iterations. If the calculated heads are found to approximate the measured heads from pre-pumping conditions, then the model will be considered calibrated and available for other numerical simulations. Once calibrated, the model can be verified by comparing measured and computed heads under pumping conditions. Water level data, available for both pre-pumping and pumping situations, would be used for this evaluation. After verification, the model can then be used to estimate the impacts on the aquifer of pumping using different management schedules.

After the numerical model is verified and able to simulate the effects of pumping, then an additional function may be added to the model. The model may be expanded so it can be used to calculate the path a particle would take in a steady-state flow field, in a given amount of time. If the location of a particle is specified, the particle tracking program can be used to calculate the location of the particle at any time and the final destination of the particle can be determined. This would be an especially useful tool in depicting how VOCs might travel from a groundwater divide created by two pumping fields. Management of pumping schedules or additional pumping may be considered during later feasibility assessments.

A particle tracking model is limited to calculations with fairly ideal mathematical conditions. Field conditions are not ideal and the model can not take into account the many factors which may affect actual VOC movement through the aquifer. However, the particle tracking model may be the best tool currently available for approximating the movement of VOC's, without resorting to much more extensive and complex modeling efforts.

As more data is collected and evaluated during the site characterization, the Work Plan may be modified to reflect the scale of effort required for modeling.

3.4 QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The overall quality assurance/quality control (QA/QC) objective is to ensure that environmental monitoring data of known and acceptable quality are provided. To attain this objective, Ebasco will implement specific procedures for field sampling, chain-of-custody, laboratory analysis, and data reporting.

Data quality objectives are qualitative and quantitative goals, in terms of precision, accuracy, reproducibility, comparability, and completeness (see Section 2.5). Ebasco has standard quality assurance/quality control plans for site investigations. In addition, the job's drilling and laboratory subcontractors have their own quality assurance/quality control programs. all of these programs were developed in compliance with the California Department of Health Services Guidelines for Quality Assurance and include the following elements:

- o Strict adherence to EPA procedures for secure sample storage, container requirements, sample preservation techniques, and laboratory analysis techniques

- o Chain-of-custody documentation

- o Duplicate sample analysis

- o Travel blank and field blank analysis

- o Analysis of known quality control samples and reference materials

To ensure that all QA/QC procedures are properly implemented, field and laboratory data checks will be conducted by Ebasco representatives. Any action which deviates from accepted QA/QC plans and policies may jeopardize the accuracy and reproducibility of sampling and laboratory results and will not be tolerated.

3.4.1 Quality Control Sampling Program

Quality control samples will be sent to the laboratory to evaluate reproducibility and analytical accuracy, the impacts of sample travel, and the effectiveness of field decontamination. Three general types of quality control samples will be analyzed. These quality control samples will include travel or trip blanks, field or equipment blanks, and duplicate samples.

The travel or trip blanks will consist of a set of 40 ml glass vials filled in the laboratory with reagent water, transported to the site, handled like a sample and returned to the laboratory for analysis, with the purpose of demonstrating that containers and samples are not contaminated in transit. The travel blank will be filled completely in the laboratory with no air bubbles and will remain closed throughout transit to ensure that no bubbles are introduced. For each sample cooler shipped, a travel blank will be sent for analysis. In this manner, any possible cross-contamination occurring among samples during shipment can be assessed. Travel blanks will be prepared for each day of field sampling in advance of initiating the sampling on that day. The travel blanks will be analyzed for volatile organics using EPA Method 624.

The field or equipment blanks will consist of a set of 40 ml glass vials filled with water that has been used to rinse the field sampling equipment after decontamination. In this manner, any possible cross-contamination occurring among samples due to the repeated use of the same sampling equipment can be assessed. A field blank will be collected after approximately every 20 soil or groundwater samples have been collected. The field blank will be analyzed for volatile organics using EPA Method 624.

A duplicate sample is a sample which is created by collecting two samples from the same sample point. Duplicate samples will be submitted to the same laboratory for the same analysis to check the reproducibility of the analytical procedures. Approximately one out of every twenty soils samples (5% of the total number of soil samples) will be collected and analyzed as duplicate samples. Duplicate samples for groundwater will be created at selected wells by splitting the sample between two sample containers. Approximately 1 out of every ten water samples (10% of the total number of water samples) will be split to evaluate the precision of laboratory data.

3.4.2 Sample Handling Procedures

All soil and groundwater samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. Sample labels will be filled out in indelible ink at the time of the sampling, and will provide the following information:

- Project name
- Sample number (alpha numerical designation)
- Date and time of sample collection
- Sampler name

Each sample will be designated by a unique alphanumeric code which will identify the sample matrix and sampling location. Identifiers will be SB for subsurface soil borings and EMW for Ebasco installed groundwater monitoring wells. Different sampling locations within each matrix type will begin with 1 and increase sequentially. Where more than one sample is collected at a location, sequential numbers will be used. Field and Travel blanks will not be specifically identified as such in the sample number, but will have a different number which will be noted in the sample log book. Such quality control samples sent to the laboratory will be sent blind, whenever possible, to eliminate laboratory bias.

As an example of this numbering system, the groundwater sample at the first groundwater well will have the sample number EMW-1, whereas the first soil sample from the second soil boring will have the sample number SB-2-1.

A permanently bound log book will be maintained by the Ebasco geologist to provide a daily record of significant events, observations, and measurements taken during field investigations. It will include persons present on site during work hours, phone numbers of key personnel, descriptions of deviations from the Work Plan, and a sample register. All log book entries will be dated, legible, and contain accurate and inclusive documentation of field activities.

Sample Containers

All sample containers will be precleaned by the laboratory according to EPA Quality Control (QC) procedures. Once opened, a container will be used immediately for the storage of a particular sample. Unused, but opened containers will be considered contaminated and will be discarded. Likewise, any unused container which, upon receipt, is found to have a loose cap or missing teflon liner (if required for that container) will be discarded.

Soil samples will be collected during drilling operations with a split-spoon sampler. The split-spoon sampler will be lined with stainless-steel or brass sample tubes 2.5 inches in diameter. Three separate tubes, each six inches long, will be placed in the split-spoon sampler. One sample tube will be used for sample description purposes, one for laboratory analysis, and one for quality control purposes as required. The ends of the soil samples contained in the sample tubes will be trimmed, covered with teflon sheets, and capped with plastic end caps. The samples will then be labeled and placed in a cooler full of ice for transportation to the laboratory.

All water samples collected for volatile organic analyses (VOA) will be retained in precleaned 40-milliliter (ml) glass vials fitted with teflon-lined silicone septums. The VOA vials will be completely filled to avoid headspace. Extreme caution will be exercised when filling the vials to avoid any turbulence which would produce contaminant volatilization. Water samples to be analyzed for metals will be collected in 1-liter polyethylene bottles with teflon lid liners. The sample bottles or vials will not be left in direct sunlight for any extended period of time. Bottles will not be reused.

Sample Preservatives

To achieve optimal sample preservation, Ebasco's subcontractor laboratory will add the appropriate preservatives, if necessary, to the containers used for water samples immediately prior to the containers being sent to the field.

Sample Transport and Custody

Each sample container will be sealed with a custody seal to preserve the integrity of the sample. Custody seals will allow for detection of unauthorized tampering of samples following sample collection up to the time of analysis, i.e., the seal will be attached so that it is necessary to break it to open the container. Custody seals will be affixed to containers before the samples leave the custody of sampling personnel.

The sample labels will be attached to the sample containers. The sample containers will then be sealed in zip-lock bags to prevent the labels from "floating" off during shipment. Glass sample containers will be securely packaged in the ice chests to avoid breakage. Soil samples will also be placed in zip-lock bags to prevent moisture from entering the samples. Chain-of-Custody forms will be completed and will accompany the samples to the laboratory.

All samples will be transported to the laboratory by courier, therefore ensuring prompt, secure arrival and meeting the requirements of "Chain-of-Custody" procedures. Samples that require refrigeration will be placed in an insulated container (ice chest) packed with ice to ensure that they remain at 4°C for laboratory testing. Each sample will be accompanied by a Chain-of-Custody Form.

The courier will sign the Chain-of-Custody form upon acceptance of the samples. At the courier's request, authorized sampling personnel will be available to open outside containers for inspection or to modify packaging.

Upon receipt of the sample at the laboratory, the designated sample custodian will proceed as follows:

- o Sign the Chain-of-Custody form(s) as a recipient of the samples.

- o Assign a laboratory ID number to the sample and enter the sample into a laboratory log book. The log book entry will include information copied from the Chain-of-Custody form and cross-checked against the sample label.

- o Examine the sample seal. Results of this examination will be noted and entered in the laboratory log book.

- o Inspect the sample container for any leakage from the ice chest. A leaking sample container will not be accepted for analysis. Results of this inspection will be noted and entered in the laboratory log book.

- o Inspect any plastic bottle containers for signs of internal pressure or escaping gas. Any such sample will be treated with exceptional caution as it may be explosive or releasing poisonous gases. Results of this inspection will be noted and entered in the laboratory log book.

- Reconcile the sample seal, label, and Chain-of-Custody Record. Any discrepancies will be resolved before assigning the sample to analysis.

- Store the sample in a secured storage room or cabinet until its assignment to an analyst.

Chain-of-Custody procedures will be used to maintain and document sample possession for legal purposes. Thus, adherence to strict document control procedures is of prime importance. The principal documents that will be used to document possession of the samples are the Chain-of-Custody Record, and the field notes.

Definition of Custody: A sample is considered to be under a person's custody if (1) it is in a person's physical possession, (2) in view of the person after he has taken possession, (3) secured by that person so that no one can tamper with the sample, or (4) secured by that person in an area which is restricted to authorized personnel.

Field Custody: The field sampler (originator) will be responsible for the care and custody of the samples from the time they are collected until they are transferred to another individual. For each sample shipment, the originator will complete a Chain-of-Custody Record entering all requested information from the sample labels. At a minimum, the record will contain the following information:

- Sample number,
- Signature of collector,
- Date and time of collection,
- Place and address of collection,
- Sample type,
- Signature of persons involved in the chain of possession, and
- Date and time of relinquishment.

Transferring Custody: The individuals receiving sample custody will cross-check the sample label and the Chain-of-Custody Record. In addition, the sample recipient will examine the samples and document any unusual conditions in the "Remarks" section on the custody form.

The person(s) relinquishing the samples will sign the custody form in the appropriate box labeled "relinquished by" and will retain a copy. The sample recipient will also sign the custody form in the appropriate box labeled "received by" and will maintain the original form. Along with their signatures, each individual will note on the form the date and time of the sample exchange. The date and time must be identical for both signatures. All sample shipments will be accompanied by the original Chain-of-Custody Record. The remaining copies will be filed and maintained in the office.

3.4.3 Equipment Decontamination Procedure

All equipment involved in drilling and field sampling activities will be decontaminated prior to any drilling and sampling. Equipment entering or leaving the site will be decontaminated as specified in the Health and Safety Plan. Decontamination facilities will be present on site. A steam cleaner will be available in the decontamination area. All drilling equipment and well casing materials will be steam-cleaned prior to use.

A sufficient number of each type of drilling and sampling equipment will be available each day so that decontamination will not need to occur during the middle of the work day. This will eliminate inefficiencies associated with decontamination during a day's activities.

The procedures for decontaminating the drilling rig, augers and other heavy equipment require brushing to remove solids and steam cleaning. The procedure for decontaminating other sampling equipment is as follows:

- place equipment on clean plastic,
- brush to remove heavy solids from split spoons and other durable equipment. Use potable water rinse for non-soiled equipment, such as bailers,
- trisodium phosphate detergent wash scrub,
- distilled deionized water rinse,

- a second distilled deionized water rinse,
- air dry,
- wrap or cover small objects when not in use, and
- place and cover all large objects on plastic.

Personnel directly involved in equipment decontamination will wear protective clothing, as specified in the Health and Safety Plan.

3.4.4 Equipment Calibration Program

Field equipment utilized for onsite measurements will be calibrated at a frequency as recommended by the equipment manufacturer or industry practice. Prior to field use, each instrument will be calibrated. Equipment to be used during the field sampling program include flame ionization detectors, pH meters, conductivity meters, temperature meters, combustible gas indicators, etc. These devices will be calibrated and adjusted at specified, predetermined intervals using equipment and standards having known valid relationships to the National Bureau of Standards or other recognized standards.

Calibration activities will be performed in accordance with written instructions provided by the manufacturer of the respective device. Test equipment found to be out of calibration will be recalibrated in accordance with the manufacturer's specification. When test equipment is found to be out of calibration, damaged, lost, or stolen, an evaluation will be made to ascertain the validity of previous test results and the acceptability of components tested since the last calibration check. Inspection and test reports will include identification of the test equipment used to perform the inspection and/or tests.

The RI Field Operations Leader(s) will be responsible for assuring that the following are implemented for field-calibrated equipment:

- A list is established to include the measuring and testing devices to be calibrated and the frequency of calibration of these devices.

The method and interval of calibration will be based on the type of device, stability characteristics, required accuracy, and other conditions affecting measurement control.

- o The screening and testing devices used are of the proper range, type, and accuracy for the test being performed.

- o A master calibration file is maintained for each measuring and testing device which includes at least the following information.

  - Name of device
  - Device serial and/or identification number
  - Results of calibration
  - Name of party performing calibration
  - Any remarks or maintenance performed

- o Measuring and testing devices are marked with calibration due dates when possible. When this marking is not possible, alternative methods of tracing the device to its calibration date (such as serialization) will be employed.

- o Develop and maintain a system for issuance, collection, and return of all screening and testing devices.

- o Methods are employed to assure proper handling, storage, and care of the test equipment in order to maintain its required accuracy.

3.5 SAMPLE ANALYSIS/DATA VALIDATION (TASK 4)

This section describes proposed soil and groundwater sample analyses and data validation procedures.

3.5.1 Soil Analysis

Descriptions of the laboratory analytical procedures proposed for all soil samples to be collected during the Remedial Investigation are presented below.

3.5.1.1 Seepage Pits Analysis

All chemical analyses performed on soil samples collected from the seepage pits will be performed by a State of California certified hazardous waste testing laboratory in accordance with recommended EPA analytical procedures.

As described in Section 3.2.1.1, soil samples will be collected every 10 feet beginning at the 10-foot depth down to 60 feet, the total depth of the borings. All soil samples will be analyzed for volatile organics using EPA Method 8240 (including cyclohexanone). Soil samples collected from the 30-foot depth will also be analyzed for semivolatile organics using EPA Method 8270, and for Total Petroleum Hydrocarbons (TPH) using EPA Method 418.1. Semivolatile organics and TPH are not anticipated to be present in the soil in significant amounts, if at all, at JPL based on previous investigations, and are being analyzed here to confirm such previous observations. The soil samples collected from the 20- and 30-foot depths will also be analyzed for California Administrative Code Title 22 Metals (Ag, As, Ba, Be, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Tl, V, and Zn) using EPA Methods 6010/7000, and cyanide using EPA Method 9010. The soil samples collected below the 30-foot depth, except for the 60-foot sample, will be archived by the analytical laboratory after being analyzed for volatile organics pending the metals and cyanide analyses on the 20-foot and 30-foot samples. If metals and/or cyanide are present in significant concentrations in the 20-foot and 30-foot samples, then the samples collected below 30 feet will also be analyzed for metals and/or cyanide. Archiving soil samples for potential future metals analyses will not be a problem since the holding time for all metals, except mercury, is 6 months (see Table 3-3). The holding time for mercury is 28 days. Greater attention will be paid to archiving soil samples for potential future cyanide analysis as the EPA holding time for cyanide is 14 days. The 60-foot

TABLE 3-3

SUMMARY OF ANALYTICAL METHODOLOGY FOR SOIL SAMPLES

Analysis	EPA Method	Maximum Holding Time	Storage Temperature
Volatile Organics	8240	14 Days	4°C
Semivolatile Organics	8270	14 Days or 7/40 Days*	4°C
Title 22 Metals	6010/7000	6 Months	4°C
Mercury	7000	28 Days	4°C
Cyanide	9010	14 Days	4°C
Total Petroleum Hydrocarbons	418.1	28 Days	4°C

* Extraction within 7 days, holding time for resulting liquids <40 days.

samples will be analyzed for all constituents mentioned above including volatile and semivolatile organics (including cyclohexanone), TPH, Title 22 metals, and cyanide.

In the event metal concentrations in the soil are reported to be greater than twenty times the RCRA Toxicity Characteristic Leaching Procedure (TCLP) regulatory value, and less than the California Administrative Code Title 22 Total Threshold Limit Concentration (TTLC), the soil will be reanalyzed using the TCLP. If the TCLP results are above the TCLP regulatory value, the soil will be considered a RCRA waste. If the TCLP results are below the TCLP regulatory value, and the original metal concentration is between ten times the California Administrative Code Title 22 Soluble Threshold Limit Concentration (STLC) and the TTLC, the sample will be re-analyzed again using the California Waste Extraction Test (WET). If the results of the WET analysis are above the STLC regulatory value, the soil will be considered a California waste.

3.5.1.2 Altadena Storm Drain Analysis

All of the soil samples collected during the storm drain assessment will be analyzed by a state certified laboratory. All of the samples will be analyzed for volatile organics using EPA Method 8240 (including cyclohexanone). Samples collected from the 10-foot depth from each boring will also be analyzed for semivolatile organics using EPA Method 8270, organochlorine pesticides and PCBs using EPA Method 8080, California Administrative Code Title 22 Metals plus strontium using EPA Methods 6010/7000, Total Petroleum Hydrocarbons using EPA Method 418.1, and cyanide using EPA Method 9010. If water runoff samples can be collected from the storm drain outlets, they will be analyzed for volatile organics using EPA Method 624.

3.5.2 <u>Groundwater Analysis</u>

Water samples will be collected from both the shallow wells and deep wells and analyzed for major anions/cations, Title 22 metals, cyanide, and volatile organics (including cyclohexanone). Samples will be collected and analyzed in the following manner: in a one liter polyethylene bottle with no additives for major anion/cation analysis to determine mass balance and charge balance; in a one liter polyethylene bottle containing a nitric acid stabilizer for metal cations (Title 22 metals); in a one liter polyethylene bottle containing a sodium hydroxide stabilizer for cyanide (EPA 9010); and in two 40-ml septum vials for volatile organics (EPA 624). An extra one liter polyethylene bottle will be filled in case additional water is needed for any of the above analyses except for volatile organics. Immediately after filling, sample bottles and vials will be labeled, sealed in plastic zip-lock brand bags, and placed on ice in a cooler for transport to the analytical laboratory.

3.5.3 Data Validation

Analytical data validation involves assessment of data quality with respect to both technical and contractual requirements. The data validation procedure will include a review of all the data collected. Examination of analytical data will ensure that the laboratory analytical results are valid and acceptable according to EPA criteria. Several items will be considered.

All samples will be transported to the analytical laboratory under Ebasco's established chain-of-custody procedures. Chain-of-custody documentation returned to Ebasco by the analytical laboratory will be examined to ensure that samples were not tampered with and reached the analytical laboratory quickly. Dates of analyses will be examined to ensure that holding times specified by the EPA were not exceeded. Analyte concentrations reported by the laboratory will be inspected for gross aberrations that might indicate major errors. Finally, all laboratory quality assurance/quality control data (e.g., instrument calibrations, blanks, spikes, recoveries, etc.) will be compared to acceptable tolerances published by the EPA to evaluate potential inaccuracies stemming from instrument malfunctions, calibration errors, operator errors, matrix effects, etc. Guidelines described in Test Methods for Evaluating Solid Waste, Third edition, SW-846, 1986, EPA will be used to evaluate laboratory QA/QC results for metals. Guidelines published in the EPA Contract Laboratory Program Statement of Work for Organic Analyses, 1990, will be used to evaluate QA/QC results for organic constituents.

Review of a data package may show that the results are acceptable for the intended needs, acceptable for some but not all intended uses, or are completely unacceptable. Data quality will be determined according to a unified approach which will utilize contractual quality control protocols. Upon completion of the data review, Ebasco will summarize its findings in the RI report.

3.6 DATA EVALUATION (TASK 5)

Existing data and data from the Remedial Investigation Site Characterization will be compiled and evaluated during this task. Concentrations of VOC's in the surface and subsurface soils will be summarized. Geologic data will be examined and correlated with borehole geophysical surveys to develop stratigraphic cross sections. Data generated from groundwater monitoring will be interpreted to establish hydraulic gradients and to estimate the flow of groundwater within the aquifer. The nature and extent of VOC's in the groundwater will be delineated and illustrated.

Potential VOC sources on-site and off-site will be evaluated for their contribution to those compounds identified in the groundwater. Correlations will be made between constituents in the groundwater and potential sources. Impacts, or the potential for impacts, to the aquifer will be evaluated.

Data evaluation may identify new data gaps and reveal whether sufficient information and understanding of the site conditions have been obtained to complete the endangerment assessment (EA) and feasibility study (FS). Additional site characterization data may be needed before the RI is completed.

3.7 ENDANGERMENT ASSESSMENT (TASK 6)

An endangerment assessment (EA) that evaluates the potential public health, welfare and environmental risks associated with contaminants underlying JPL will be performed after the RI is completed. The EA will reflect currently available information in addition to the results of the final Remedial Investigation. The EA will provide a baseline public health evaluation of the site conditions in the absence of remedial action.

The EA will identify the chemicals of concern (indicator chemicals), potential exposure pathways, information on the toxicity of site contaminants, and present a semiquantitative assessment of site-specific risks.

The completion of this EA will include the following four steps:

- o <u>Data Analysis and Final Selection of Chemicals of Concern and Exposure Pathways</u>. Current information suggests that VOCs represent sources of candidate chemicals of concern. An indicator list of chemicals of concern based on the RI data and potential exposure pathways evaluated as part of the RI will serve as a basis for the EA. During the progress of and upon completion of the Remedial Investigation, any new data or information will be evaluated to assess if additional chemicals or pathways should be considered and included in the final Level II EA.

- o <u>Estimation of Exposure Point Concentrations</u>. Results of the complete RI sampling and analysis program and the environmental modeling effort will be designed to estimate environmental concentrations at points of exposure for each exposure scenario to be considered in the EA. Concentrations will be estimated in each environmental medium-air, surface water, groundwater, and/or soil through which potential exposure could occur.

- o <u>Comparison to Standards and Criteria</u>. EPA's guidelines indicate that the projected concentrations of chemicals of concern at exposure points should be compared to applicable or relevant and appropriate requirements (ARARs). At the present time, EPA considers the Safe Drinking Water Act Maximum Contaminant Levels (MCLs) and Clean Air Act National Ambient Air Quality Standards to be federal ARARs applicable to ambient environmental concentrations of contaminants. Other federal and state standards may also be ARARs for a particular site (see Section 2.4). The determination of exactly which requirements are applicable or relevant and appropriate for an individual site is made on a site-specific basis. Other guidelines that may be used are the Clean Water Act water quality criteria and adjusted water quality criteria and the health advisories that EPA's Office of Drinking Water has developed.

- <u>Quantitative Risk Estimation</u>. Some VOCs at JPL lack established federal standards that are applicable for all specific pathways of interest. Therefore, under EPA guidance on risk assessments, a quantitative assessment of possible risk will be performed for all chemicals of concern at the site.

  The potential receptors, or populations at risk, will be characterized to assess the potential adverse health effects associated with the site.

  Exposure point concentrations will be combined with standard exposure assumptions to estimate the intake of each contaminant via each exposure pathway. If it appears possible that exposure could occur via more than one pathway for some populations, the total intake will be calculated by adding the intakes from each pathway.

  Critical toxicity values (i.e., numerical values derived from dose-response information for individual compounds) will be used in conjunction with intake determinations to characterize risk. This effort will require interpretation of the applicability of toxicity data to the specific exposure conditions expected to occur at the site.

  Critical toxicity values developed by EPA as reported in IRIS or by the Carcinogen Assessment Group (CAG) will be used when available. If values for a particular chemical are not available on IRIS or from CAG, other EPA sources may be used for critical toxicity values, subject to EPA approval. For other chemicals, two different types of critical toxicity values may be used.

- The oral risk reference dose for chronic exposure (RfD), formerly referred to as the allowable intake for chronic exposure (AIC) or the allowable daily intake (ADI). The RfD values and other health-based critical toxicity values represent levels of exposure below which adverse health effects are not expected to occur. They are derived by applying uncertainty factors to No-Observed-Adverse-Effect Levels (NOAEL) or Lowest-Observed-Adverse-Effect Levels (LOAEL) from animal studies and/or epidemiological studies.

- The carcinogen potency factor (for carcinogens only).

Noncarcinogenic Risks. The estimated chronic daily intake (CDI) at exposure points will be compared to the RfD to assess potential hazards to noncarcinogenic contaminants. Where the CDI exceeds the RfD, an unacceptable public health risk may be presumed to exist. Where exposures are to more than one chemical, a hazard index (HI) will be computed. This index sums the ratios of the CDI to the RfD over all the chemicals of concern present. This approach assumes that the risks due to exposure to multiple chemicals are additive. This assumption may be valid for compounds which have the same target organ and act via the same mechanisms. If the hazard index results in a value greater than unity, to the degree possible, the compounds in the mixture will be separated by critical effect and separate hazard indices will be derived for each effect.

Throughout the risk assessment process, risks from different exposure pathways will be estimated separately. However, the possible effects of multimedia exposure will be evaluated by summing the hazard indices for inhalation and oral exposures. This evaluation will assure that acceptable levels are not being exceeded by combined intakes when multiple exposure pathways exist.

Potential Carcinogens. For potential carcinogens the carcinogenic potency factor, defined as the estimated slope of a dose-response curve, will be used to predict possible cancer risks at low dose levels. This factor is generally estimated from the upper 95 percent confidence limit of the extrapolation model and has been calculated by EPA for some carcinogens. Risks are assumed to be directly related to intake at low levels of exposure. Expressed as an equation, the model for a particular exposure route is:

Risk = Estimated Chronic Daily Intake x Carcinogenic Potency Factor

Assumptions will be made that cancer risks from various exposure routes are additive. Thus, the result of the assessment will be an upper bound estimate of the total possible carcinogenic risk for each significant exposure point.

The results of the EA will serve as a basis for setting remedial action cleanup levels for the media of concern.

3.8 SUPPLEMENTAL FIELD ACTIVITIES

Concurrent with implementing the RI Phase I field investigation activities, Ebasco and JPL personnel will be evaluating the need for additional field studies. The factors that could potentially be considered during this evaluation include the following:

- The discovery of previously unsuspected types, concentrations, or quantities of contaminants. The presence of contaminants which were not identified during scoping activities may require demobilization and additional planning.

- Additional site characterization activities in case the site is not adequately characterized in one phase.

- The need for interaction with, and feedback from, agencies, the public and JPL personnel. If additional time is needed for review of the data generated during RI Phase I, it may be necessary to demobilize the field sampling team(s) until comments and direction can be received from all interested parties.

- The preliminary or summary results of treatability studies may indicate that additional contaminants and/or parameters need to be tested or that existing contaminants need to be better defined.

3.9 REMEDIAL INVESTIGATION REPORT (TASK 8)

A draft report will be produced to present the analytical data, data evaluations, and conclusions from the Remedial Investigation (RI). This draft will be submitted to JPL for review and comments before being submitted to the EPA and State of California for review. The general outline for the draft RI report is presented in Table 3-4. The RI report will be prepared after the RI field activities have been completed and before completion of the draft FS report.

TABLE 3-4

OUTLINE OF REMEDIAL INVESTIGATION REPORT

EXECUTIVE SUMMARY

1.0 INTRODUCTION
- 1.1 Purpose of Report
- 1.2 Site Background
  - 1.2.1 Site Description
  - 1.2.2 Site History
  - 1.2.3 Hydrology
  - 1.2.4 Geology
  - 1.2.5 Previous Investigations
- 1.3 Report Organization

2.0 RI INVESTIGATION

(Includes field activities associated with site characterization. If technical memoranda documenting field activities are prepared, they will be included in an appendix and summarized in the following sections.)
- 2.1 Contaminant Source Investigations
  - 2.1.1 Drilling Methods
  - 2.1.2 Sampling Methods
- 2.2 Groundwater Investigations
  - 2.2.1 Drilling Methods
  - 2.2.2 Well Installation Procedures
  - 2.2.3 Sampling Methods

3.0 PHYSICAL CHARACTERISTICS OF SITE

(Includes results of field activities that determined physical characteristics.)
- 3.1 Hydrology
  - 3.1.1 Groundwater Level Measurements
  - 3.1.2 Aquifer Characteristics
- 3.2 Geology

4.0 NATURE AND EXTENT OF CONTAMINATION

(Presents the results of site characterization, both natural and chemical components and contaminants.)
- 4.1 Contaminant Source Analyses
  - 4.1.1 Data Validation
- 4.2 Groundwater Analyses
  - 4.2.1 Data Validation

TABLE 3-4 (Continued)

OUTLINE OF REMEDIAL INVESTIGATION REPORT

5.0 CONTAMINANT FATE AND TRANSPORT
- 5.1 Potential Routes of Migration
- 5.2 Contaminant Persistence
- 5.3 Contaminant Migration
  - 5.3.1 Modeling Methods and Results

6.0 RISK EVALUATION
- 6.1 Public Health Evaluation
- 6.2 Environmental Evaluation

7.0 SUMMARY AND CONCLUSIONS
- 7.1 Summary
  - 7.1.1 Nature and Extent of Contamination
  - 7.1.2 Fate and Transport
  - 7.1.3 Risk Evaluation
- 7.2 Conclusions
  - 7.2.1 Data Limitations and Recommendations for Future Work
  - 7.2.2 Recommended Remedial Action Objectives

8.0 REFERENCES

APPENDICES

A. Boring Log and Well Completion Forms
B. Analytical Data and QA/QC Evaluation Results

4.0 FS PHASE I: FEASIBILITY STUDY DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES (TASK 9)

The feasibility study (FS) development and screening of remedial alternatives for VOCs in subsurface soil and groundwater underlying JPL will consist of two phases. In the initial phase of the FS, a preliminary list of remedial alternatives for both media of concern will be identified and screened for effectiveness in protecting human health and the environment. This preliminary list of alternatives will be evaluated in detail to identify those technologies effective for a specific operable unit and each media as a whole. Once the alternatives have been screened in detail, the last effort in phase one of the FS will be to conduct a treatability study for those technologies deemed worthy of undergoing the final evaluation and selection in phase two. Phase two of the FS will involve a detailed analysis of each alternative based on the nine basic criteria used to evaluate remedial alternatives to reduce contaminant concentrations to acceptable levels, and prevent exposures to these compounds, or some combination of elimination, reduction, and exposure prevention.

In developing the remedial alternatives two issues will need to be addressed. The initial issue will be to identify the volumes or areas of each media to which treatment and containment actions may be applied, possibly in combination with excavation, disposal, or institutional actions. The media to be treated or contained will be determined once RI data on the nature and extent of contamination are obtained, ARARs reviewed, and risks associated with no action evaluated. The second issue to be addressed in this phase of the FS will be to identify any newly developed technologies that might be effective for the contaminants and media of concern. The information obtained during these two activities will serve as the basis criteria identified by EPA for selecting remedial alternatives. The results of this detailed analysis of alternatives will serve as a basis for selecting a remedial alternative for each media or operable unit of concern in the record of decision.

4.1 IDENTIFICATION AND SCREENING OF REMEDIAL ALTERNATIVES

Remedial alternatives for each media or operable unit of concern will be identified and screened for effectiveness in protecting human health and the environment as the RI proceeds. Data generated during the RI, including the nature and extent of organic compounds in groundwater and subsurface soil and descriptions of physical limitations for implementing remedial technologies will be needed before this phase can be initiated. This process will focus on identifying the technologies that eliminate the substances of concern at the site, for the selection of which alternatives and technologies will undergo detailed analysis and later treatability studies.

4.1.1 Preliminary Selection of Remedial Alternatives

A preliminary selection of remedial alternatives will serve as the basis for all subsequent evaluations. The primary objective of this phase of the FS is to select and develop alternatives that protect human health and the environment and encompass a range of appropriate waste management options. Appropriate waste management options may involve eliminating the hazardous substances at the site, reducing hazardous substances to acceptable levels, and preventing exposure to hazardous substances or some combination of elimination, reduction, and exposure prevention. Alternatives will be developed concurrently with the RI site characterization, with the results of one influencing the other in an iterative fashion.

In developing alternatives, two important activities will occur. First, volumes or areas of media will be identified to which treatment and containment actions may be applied, possibly in combination with excavation, disposal, or institutional actions. The media to be treated or contained will be determined by information on the nature and extent of contamination, ARARs, and risk factors. Second, the remedial action alternatives and associated technologies identified during project planning and any newly identified technologies will be screened to identify those that would be effective for the contaminants and media of interest at the site. The information obtained during these two activities will be used in assembling technologies (and the media to which they will be applied) into alternatives for the site as a whole or a specific operable unit.

Alternatives for remediation will be developed by assembling combinations of technologies, and the media to which they would be applied, into alternatives that address contamination on a site-wide basis or for an identified operable unit. This process consists of six general steps (EPA 1988) which are to:

- Develop remedial action objectives specifying the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of treatment and containment alternatives to be developed. The objectives developed are based on contaminant-specific ARARs, when available, and risk-related factors.

- Develop general response actions for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, that may be taken to satisfy the remedial action objectives for the sites.

- Identify volumes or areas of media to which general response actions might be applied, taking into account the requirements for protectiveness as identified in the remedial action objectives and the chemical and physical characterization of the site.

- Identify and screen the technologies applicable to each general response action to eliminate those that cannot be implemented technically at the site. The general response actions are further defined to specify remedial technology types.

- Identify and evaluate technology process options to select a representative process for each technology type retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type.

- Assemble the selected representative technologies into alternatives representing a range of treatment and containment combinations, as appropriate.

Alternatives will be developed that will provide decision makers with an appropriate range of options and sufficient information to adequately compare alternatives against one another. In developing alternatives, the range of options will vary depending on RI Phase I Site Characterization of site-specific conditions. A description of the preliminary source control and response actions that have been developed are summarized in Table 4-1.

4.1.2 Screening of Alternatives

Screening of the alternatives identified will occur as potentially applicable technology types and process options are reduced by evaluating the options with respect to technical implementability. The term "technology types" refers to general categories of technologies, such as chemical treatment, thermal destruction, solidification, capping, or dewatering. The term "technology process options" refers to specific processes within each technology type. For example, the chemical treatment technology type would include such process options as precipitation, ion exchange, and oxidation/reduction.

Technology types and process options will be identified during a literature search by drawing on a variety of sources including references developed for application to Superfund sites and more standard engineering texts not specifically directed toward hazardous waste sites.

During this screening step, process options and entire technology types will be eliminated from further consideration on the basis of technical implementability. This will be accomplished by using readily available information from the RI site characterization on contaminant types and concentrations and onsite characteristics to screen out technologies and process options that cannot be effectively implemented.

4.1.3 Alternative Selection for Detailed Analysis

Once the screening of alternatives is complete, the selection of which alternates will go on for detailed analyses will occur. In this step of alternative development, the technology processes considered to be

TABLE 4-1

PRELIMINARY REMEDIAL ALTERNATIVES FOR SUBSURFACE SOIL AND GROUNDWATER AT JPL

Media	Remedial Action	Potential Alternatives	Comments/Additional Data
Subsurface Soil	o No Action	o Monitor leachate/volatile organic gases/surface runoff dust/groundwater o Install fencing	o Perform risk assessment o Perform hydrogeological investigations
	o Containment	o Source Control - Cover material o Monitor leachate/volatile organic gases/surface runoff/dust/groundwater o Vent and collect volatile organic gases o Collect leachate	o Perform hydrogeological investigations o Perform risk assessment o Not a preferred SARA alternative
	o Offsite Treatment/Disposal	o Excavate o Treat - Incineration - Fixation - Chemical Precipitation - Biodegradation	o Perform risk assessment o Treatability study o Economics of hauling o Control gas emissions
	o Onsite Treatment/Disposal	o Excavate o Treat - Incineration - Fixation - Chemical Precipitation - Biodegradation o Disposal Cell	o Perform risk assessment o Treatability study o SARA preferred alternative o Control gas emissions
	o In-Situ Treatment	o Inject chemicals/air/steam/microorganisms/nutrients - Fixation - Chemical precipitation - Biodegradation - Hot air/steam stripping - Soil flushing	o Control gas emissions o Perform risk assessment o Treatability study o Lowest health risk o SARA preferred alternative

TABLE 4-1 (Continued)

PRELIMINARY REMEDIAL ALTERNATIVES FOR SUBSURFACE
SOIL AND GROUNDWATER AT JPL

Media	Remedial Action	Potential Alternatives	Comments/Additional Data
Groundwater	o No action	o Monitor	o Possible migration offsite o Not a preferred SARA alternative
	o Containment	o Physical Barriers o Monitor	o Perform risk assessment o Not a preferred SARA alternative
	o Pump and Treat	o Air Stripping o Activated carbon absorption o Biodegradation o Photolysis	o Treatability study o Pumping cost
	o In-Situ Treatment	o Biological o Precipitation	o Collect more samples for contamination assessment o Treatability study o Preferred SARA alternative

implementable will be evaluated in greater detail before selecting one process to represent each technology type. One representative process will be selected, if possible, for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. The representative process will provide a basis for developing performance specifications during preliminary design; however, the specific process actually used to implement the remedial action at a site may not be selected until the remedial design phase. In some cases more than one process option may be selected for a technology type. This may be done if two or more processes are sufficiently different in their performance or effect that one would not adequately represent the other. An example might be the technology for groundwater treatment where many potential technologies appear feasible.

Process options will be evaluated using the same criteria of effectiveness, implementability, and cost that are used to screen alternatives prior to the detailed analysis. An important distinction to make is that at this time these criteria will be applied only to technologies and the general response actions they are intended to satisfy and not to the site as a whole. Furthermore, the evaluation will focus on effectiveness factors at this stage with less effort directed at the implementability and cost evaluation.

4.2 TREATABILITY STUDIES (TASK 7)

Treatability studies that assess the effectiveness of a technology to reduce the hazards posed by the presence of chemicals in a media may be needed once the remedial alternatives have been identified and screened. The goal of any treatability study is to use an experimental bench top treatment system to test whether that system can meet the remedial design specifications set forth in the endangerment assessment. Once a list of remedial alternatives have been identified and screened for both groundwater and subsurface soil, one or more treatment technologies may be treated as part of this effort.

Several generic types of bench-scale tests may be required for subsurface soil containing VOCs including these types of tests:

- o Vapor extraction,
- o In-situ biorestoration,
- o Incineration, and
- o Fixation

For groundwater containing VOCs, the generic type of bench scale treatment tests include:

- o Air stripping,
- o Photolysis, and
- o Carbon absorption

The approach to be used to conduct the treatability studies is described in the following section.

4.2.1 <u>Subsurface Soil Treatability Tests</u>

Subsurface soil treatability tests may be conducted to assess which of the applicable treatment technologies identified as part of the feasibility study will be effective in removing or reducing VOCs contained in source areas present at the site. There is virtually no information at this time about the nature and extent of subsurface soil containing VOCs at the site. There is no data available to evaluate whether these source areas are accessible for excavation or whether in-situ methods will be required. Many of the potential source locations identified to date are located in areas that are inaccessible to heavy machinery. These locations are under buildings or in tightly confined areas between buildings. Because of these constraints, the treatability studies will probably focus on in-situ treatment or removal systems.

The physical-chemical treatment systems that may be investigated include:

- o Vapor extraction,
- o In-situ biorestoration,
- o Incineration, and
- o Fixation

The treatability study for vapor extraction of VOCs in subsurface soil will demonstrate:

- o Removal efficiency of VOCs from soil particles,
- o Flow rate of vapors through the soil column, and
- o Above ground degradation mechanisms

The treatability study for in-situ biorestoration of VOCs in subsurface soil will demonstrate:

- o The type of microorganisms required;

- o Removal efficiency of microorganisms for various VOCs;

- o Optimum moisture, nutrient, and oxygen content of soil required for biorestoration;

- o Removal efficiency of acclimated versus nonacclimated microorganisms.

Should the feasibility study indicate that subsurface soil containing VOCs can be excavated and treated above ground, a treatability study for surface technologies such as incineration or fixation will be investigated. The treatability study for incineration of VOC containing soil sill demonstrate:

- o The physical, chemical, and thermodynamic properties of the soil;

- o Characteristics of the incinerators appropriate for this effort;

- o The residence times, temperatures and oxygen required to achieve a 99.99 percent removal efficiency, and

- o The fate of all contaminants including products of incomplete combustion.

The treatability study for fixation of VOC containing soil will demonstrate:

- o The optimal fixation mixture required to render the VOCs immobile;

- o The preferred methods for handling the soil to meet the fixation requirements, and

- o The contaminants leachability when the fixed soil is subject to a Waste Extraction Test.

4.2.2 <u>Groundwater Treatability Tests</u>

Groundwater treatability tests may be conducted to assess which of the applicable treatment technologies identified as part of the feasibility study will be most effective in removing or reducing VOCs from groundwater underlying JPL. The treatment system in place for the City of Pasadena production wells is currently treating large volumes of VOC contaminated groundwater and can serve as a model for systems installed for JPL, however newer technologies may prove more effective and less costly. Accordingly, physical-chemical treatment methods which may be investigated include:

- o Air stripping,
- o Photolysis, and
- o Carbon adsorption

The treatability study for air stripping of VOC containing groundwater will demonstrate:

- o Optimum temperature required for maximum contamination removal efficiency;

- o Optimum pH adjustment for arriving at the maximum rate of contaminant removal;

- o Provide guidance for full scale stripping system; and

- o The potential for meeting the guidelines for air and water requirements.

The treatability study for photolysis of VOC containing groundwater will demonstrate:

- o Optimum photochemical or mixed photochemical and chemical process for affecting all compounds of concern;

- o Impact of sensitive photochemical species present in water on removal efficiency;

- o Optimum radiation source absorbed by the target species;

- o The presence of radiation breakdown products resulting from treatment.

The treatability study for carbon adsorption of VOC containing groundwater may demonstrate:

- o The optimum surface area required for maximum adsorption capacity;

- o The optimum pore size for maximum adsorption capacity;

- o The approximate pH and temperature for optimizing adsorption;

- o The rate of adsorption;

- o The effect of suspended solids on adsorption and backwash requirements;

- o The effect of other contaminants, if any, on the operation of the system; and

- o Provide guidance for a full scale treatment system.

5.0 FS PHASE II: REMEDIAL ALTERNATIVES EVALUATION AND SELECTION (TASK 10)

The last phase of the JPL FS will focus on the final evaluation and selection of remedial alternatives for both the groundwater and subsurface soil. This final FS will contain analyses of relevant information needed to select site remedies. During this detailed evaluation and analysis, each alternative that has been carried forward from the preliminary screening and treatability studies will be assessed against the nine standard evaluation criteria discussed later in this section.

The results of this detailed evaluation will be arrayed so that comparisons can be made among alternatives and the key deficiencies among alternatives can be identified. This approach to evaluating alternatives will be designed to provide sufficient information to adequately compare the alternative technologies, select appropriate remedies, and demonstrate that all statutory requirements are met so that a record of decision (ROD) can be drafted.

The specific requirements of CERCLA that will be addressed in the ROD and supported by findings of this final FS report are:

- The remedy be protective of human health and the environment;
- ARAR's are attained or provide justification for invoking a waiver;
- The technologies and alternative be cost effective;
- That permanent solutions are utilized to the extend possible; and
- The technologies selected reduce toxicity, mobility or volume of the affected media.

In addition, CERCLA places an emphasis on evaluating long-term effectiveness and related considerations for each of the alternative remedial actions. These statutory considerations include:

- the long-term uncertainties associated with land disposal;
- the goals, objectives, and requirements of the Solid Waste Disposal Act;
- the persistence, toxicity, and mobility of hazardous substances and their constituents, and their ability to bioaccumulate;
- short- and long-term potential for adverse health effects from human exposure;
- long-term maintenance costs;
- the potential for future remedial action costs if the alternative remedial action in question were to fail; and
- the potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment.

Nine evaluation criteria have been developed to address the CERCLA requirements and considerations listed above as well as additional technical and policy considerations that have proven to be important for selecting among remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses during the FS and for subsequently selecting an appropriate remedial action. The evaluation criteria are divided into three groups:

<u>Primary Balancing Factors</u>

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost

Threshold Factors

- o Compliance with ARARs
- o Overall protection of human health and the environment

Modifying Considerations

- o State acceptance
- o Community acceptance

5.1 DETAILED ANALYSIS OF ALTERNATIVES

The last phase of the FS will involve a detailed analysis of alternatives and will precede the actual selection of remedy (ies). The extent to which alternatives will be analyzed during the detailed analysis will be influenced by the available data, the number and types of alternatives being analyzed, and the degree to which alternatives were previously analyzed during their development and screening.

The evaluations conducted during the detailed analysis phase will build on previous evaluations conducted during the development and screening of alternatives. This phase will also incorporate any treatability study data and any additional site characterization information that might be collected during additional RI activities.

A detailed analysis of alternatives will consist of the following components:

- o Further definition of each alternative, if appropriate, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.

- o An assessment and a summary of each alternative against the nine evaluation criteria.

- o A comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.

The detailed analysis provides the means by which facts are assembled and evaluated to develop the rationale for a remedy selection. Thus, the requirements of the remedy selection process ensures that the FS analysis provides the sufficient quantity and quality of information to simplify the transition between the FS report and the actual selection of a remedy. The analysis process described here has been developed on the basis of statutory requirements of CERCLA Section 121; earlier program initiatives promulgated in the November 20, 1985, NCP; the existing "Guidance on Remedial Investigations and Feasibility Studies Under CERCLA," dated May 1985; and site-specific experience gained in the Superfund program. The nine evaluation criteria listed in this section encompass technical, cost, and institutional considerations; compliance with specific statutory requirements; and state and community acceptance.

5.1.1 Overall Protection of Human Health and Environment

The overall protection of human health and environment is one of the most important criterion in the FS process and focuses whether each remedial alternative evaluated meets the requirement protecting human health and the environment. This evaluation is based on a composite of factors assessed under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Evaluation of the overall protectiveness of an alternative during the RI/FS will focus on how a specific alternative achieves protection over time and how site risks are reduced. The analysis will indicate how each VOC source is to be eliminated, reduced, or controlled for each alternative.

5.1.2 Compliance with ARAR's

Compliance with ARAR's will be used as a criterion to determine how each alternative complies with applicable or relevant and appropriate Federal and State requirements, as defined in CERCLA Section 121. There are three general categories of ARARs: chemical-, location-, and action-specific. ARARs for each category have been identified in previous stages of the RI/FS process (see Section 2.4). The detailed analysis will summarize which requirements are applicable or relevant and appropriate to an alternative and describe how the alternative meets these requirements. When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA will be discussed.

Other information in the form of advisories, criteria, and guidance that are not ARARs may be available, but because they may be necessary to ensure protectiveness and are appropriate for use in a specific alternative they will still be considered in the analysis. These to-be-considered (TBC) criteria will be included in the detailed analysis if the lead and support agencies agree that their inclusion is necessary and appropriate.

The following will be addressed for each alternative during the detailed analysis of ARARs:

- o Compliance with chemical-specific ARARs (e.g., MCLs)--This factor addresses whether the ARARs can be met, and if not, whether a waiver may be appropriate.

- o Compliance with action-specific ARARs (e.g., RCRA minimum technology standards)--It must be determined whether ARARs can be met or waived.

- o Compliance with location--specific ARARs (e.g., preservation of historic sites)--As with other ARAR-related factors, this involves a consideration of whether the ARARs can be met or whether a waiver is appropriate.

- o Compliance with appropriate criteria, advisories, and guidances--This involves a consideration of how well the alternative meets Federal and State guidelines that are not ARARs (e.g., not promulgated) but have been identified by lead and support agencies as TBCs because they have been determined to be necessary to ensure protection of human health and the environment and are appropriate for the circumstances of the site.

The actual determination of which requirements are applicable or relevant and appropriate will be made by the lead regulatory agency in consultation with other agencies. A summary of these ARARs and whether they will be attained by a specific alternative will be presented in an appendix to the FS report.

5.1.3 Long-Term Effectiveness and Permanence

The evaluation of alternatives for long-term effectiveness and permanence addresses whether the remedial action will mitigate risk remaining at the site after the response objectives have been met. The primary focus of this evaluation criterion will be the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated materials. The following components of the criterion will be addressed for each alternative:

- Magnitude of remaining risk--This factor assesses the residual risk remaining from untreated materials or treatment residuals at the conclusion of remedial activities. The potential for this risk may be measured by numerical standards such as cancer risk levels or the volume or concentration of contaminants in waste media, or treatment residuals remaining on the site. The hazardous characteristics of the residuals will be based on their toxicity, mobility, and ability to bioaccumulate.

- Adequacy of controls--This factor assesses the adequacy and suitability of controls, if any, that are used to manage treatment residuals or untreated materials that remain at the site. These may include an assessment of containment systems and institutional controls to ensure that any exposure to human and environmental receptors is within protective levels.

- Reliability of controls--This factor addresses the long-term reliability of management controls for providing continued protection from residuals. This includes the assessment of need to replace technical components of the alternative and the risks posed should the remedial action need replacement.

initially identified for specific technologies during the development and screening of alternatives and is addressed again in the detailed analysis for the alternative as a whole.

- Reliability of technology--This focuses on the ability of a technology to meet specified process efficiencies or performance goals. The likelihood that technical problems will lead to schedule delays will be considered as well.

- Ease of undertaking additional remedial action--This includes a discussion of what, if any, future remedial actions may need to be undertaken and the difficulty in implementing such additional actions. This is particularly applicable for an FS addressing an interim action at a site where additional operable units may be analyzed at a later time.

- Monitoring considerations--This addresses the ability to monitor the remedies' effectiveness and includes an evaluation of the risks of exposure should monitoring be insufficient to detect a system failure.

o Administrative feasibility

  - Activities needed to coordinate with other offices and agencies such as obtaining permits for offsite activities or rights-of-way for construction.

o Availability of services and materials

  - Availability of adequate offsite treatment, storage capacity, and disposal services

  - Availability of necessary equipment and specialists and provisions to ensure any necessary additional resources

  - Timing of the availability of technologies under consideration

- Availability of services and materials, plus the potential for obtaining competitive bids, which may be particularly important for innovative technologies.

5.1.7 Costs

A comprehensive discussion of costing procedures for CERCLA sites is contained in the Remedial Action Costing Procedures Manual (USEPA 1985). The application of cost estimates to alternatives evaluation is discussed in the following paragraphs.

Capital Costs. Capital costs consist of direct (construction) and indirect (nonconstruction and overhead) costs. Direct costs include expenditures for the equipment, labor, and materials necessary to install remedial actions. Indirect costs include expenditures for engineering, financial, and other services that are not part of actual installation activities but are required to complete the installation of remedial alternatives. (Sales taxes normally do not apply to Superfund actions). Costs that must be incurred in the future as part of the remedial action alternative will be identified and noted for the year in which they will occur. The distribution of costs over time will be a critical factor in consideration between technologies.

Direct capital costs may include the following:

- o Construction costs--Costs of materials, labor and equipment required to complete a remedial action.
- o Equipment costs--Costs of remedial action and service equipment necessary to enact the remedy until the site remedy is complete.
- o Land and site-development costs--Expenses associated with the purchase of land and the site preparation costs of existing property.
- o Buildings and services costs--Costs of process and nonprocess buildings, utility connections, purchased services, and disposal costs.

- Relocation expenses--Costs of temporary or permanent accommodations for affected nearby residents.

- Disposal costs--Costs of transporting and disposing of waste material such as drums and contaminated soils.

Indirect capital costs may include:

- Engineering expenses--Costs of administration, design, construction supervision, drafting, and treatability testing.

- Legal fees and license or permit costs--Administrative and technical costs necessary to obtain licenses and permits for installation and operation.

- Startup and shakedown costs--Costs incurred during remedial action startup.

- Contingency allowances--Funds to cover costs resulting from unforeseen circumstances, such as adverse weather conditions, strikes, and inadequate site characterization.

Annual Costs. Annual costs are post-construction costs necessary to ensure the continued effectiveness of a remedial action. Although some annual costs may be borne by other agencies, this distinction will not be called out in the FS. The following annual cost components will be considered:

- Operating labor costs--Wages, salaries, training, overhead, and fringe benefits associated with the labor needed for post-construction operations.

- Maintenance materials and labor costs--Costs for labor, parts, and other resources required for routine maintenance of facilities and equipment.

- o Auxiliary materials and energy--Costs of such items and electricity for treatment plant operations, water and sewer services, and fuel.

- o Disposal of residues--Costs to treat or dispose of residuals such as sludges from treatment processes or spent activated carbon.

- o Purchased services--Sampling costs, laboratory fees, and professional fees for which the need can be predicted.

- o Administrative costs--Costs associated with the administration or remedial action O&M not included under other categories.

- o Insurance, taxes, and licensing costs--Costs of such items as liability and sudden accidental insurance; real estate taxes on purchased land or rights-of-way; licensing fees for certain technologies; and permit renewal and reporting costs.

- o Maintenance reserve and contingency funds--Annual payments into escrow funds to cover costs of anticipated replacement or rebuilding of equipment and any large unanticipated O&M costs.

- o Rehabilitation costs--Cost for maintaining equipment or structures that wear out over time.

- o Costs of periodic site reviews--Costs for site reviews that are conducted at least every 5 years if wastes above health-based levels remain at the site.

The costs of potential future remedial actions will be addressed, and if appropriate, will be included when there is a reasonable expectation that a major component of the alternative will fail and require replacement to prevent significant exposure to contaminants. Analysis, described under Section 5.1.3, "Long-term Effectiveness and Permanence," will be used to determine which alternatives may result in future costs. It is not expected that a detailed statistical analysis will be required to identify probable future costs. Rather, qualitative engineering judgment will be used and the rationale should be well documented in the FS report.

Accuracy of Cost Estimates. Site characterization and treatability investigation information will permit the user to refine cost estimates for remedial action alternatives. An accuracy of +50 percent to -30 percent of cost estimates will be used.

Present Worth Analysis. A present worth analysis will be used to evaluate expenditures that occur over different time periods by discounting all future costs to 1991. This will allow the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in this year and disbursed as needed, will be sufficient to cover all costs associated with the remedial action over its planned life.

In conducting the present worth analysis, assumptions will be made regarding the discount rate and the period of performance. A discount rate of 5 percent before taxes and after inflation will be assumed. Estimates of costs in each of the planning years will be made in constant dollars, representing the general purchasing power at the time of construction. In general, the period of performance will not exceed 30 years for the purpose of the detailed analysis.

Cost Sensitivity Analysis. After the present worth of each remedial action alternative is calculated, individual costs may be evaluated through a sensitivity analysis if there is sufficient uncertainty concerning specific assumptions. A sensitivity analysis assesses the effect that variations in specific design assumptions, implementation, operation, discount rate, and effective life of an alternative can have on the estimated cost of the alternative. These assumptions depend on the accuracy of the data developed during the site characterization and treatability investigation and on predictions of the technology's future behavior. Therefore, these assumptions are subject to varying degrees of uncertainty from site to site. The potential effect on the cost of an alternative because of these uncertainties can be observed by varying the assumptions and noting the effects on estimated costs. Sensitivity analyses can also be used to optimize the design of a remedial action alternative, particularly when design parameters are interdependent such as treatment plant capacity for contaminated groundwater and the length of the period of performance.

Use of sensitivity analyses will be considered for the factors that can significantly change overall costs of an alternative with only small changes in their values, especially if the factors have a high degree of uncertainty associated with them. Other factors chosen for analysis may include those factors for which the expected (or estimated) value is highly uncertain. The results of such an analysis can be used to identify worst-case scenarios and to revise estimates of contingency or reserve funds.

The following factors are potential candidates for consideration in conducting a sensitivity analysis:

- The effective life of a remedial action,
- The O&M costs,
- The duration of cleanup,
- The volume of contaminated material, given the uncertainty about site conditions,
- Other design parameters (e.g., the size of the treatment system), and
- The discount rate (5 percent will be used to compare alternative costs, however, a range of 3 to 10 percent may be used to investigate uncertainties)

The result of sensitivity analysis will be discussed during the comparison of alternatives. Areas of uncertainty that may have a significant effect on the cost of an alternative will be highlighted, and a rationale will be presented for selection of the most probable value of the parameter.

5.1.8 State Acceptance

This assessment evaluates the technical and administrative issues and concerns the State of California may have regarding each of the alternatives.

The analysis will be limited to formal comments made during previous phases of the RI/FS and will describe the process used to obtain input from other agencies during preparation of the RI/FS. This may include meetings, opportunities for agency review, and the transmittal of comments between agencies.

During this process, formal comments can be provided during the comment period on the FS report. These comments will be fully evaluated during preparation of the ROD or administrative agreement and the responsiveness summary.

5.1.9 Community Acceptance

Acceptance of the alternative by the City of Pasadena and surrounding communities will be important in selecting an alternative. This assessment incorporates public input into the analysis of alternatives. There are several points in the RI/FS process at which the public may have previously provided comments to the lead agency. As with the previous assessment of state acceptance, there is no formal opportunity for public comment during the preparation of the FS report. Formal public comments are provided during the 30-day public comment period on the FS report. Public concerns or comments will be addressed in the ROD or administrative agreement and responsiveness summary. When community positions on specific alternatives have been documented during preparation of the RI/FS, the detailed analysis will address those features the community support, has reservation about, or opposes.

6.0 PROJECT MANAGEMENT

The proposed project management activities for the RI/FS of the JPL site will be discussed in two separate sections. The proposed management organization and approach will be presented followed by the proposed quality assurance and data management structure. These descriptions will serve as the basis from which the proposed activities will be conducted.

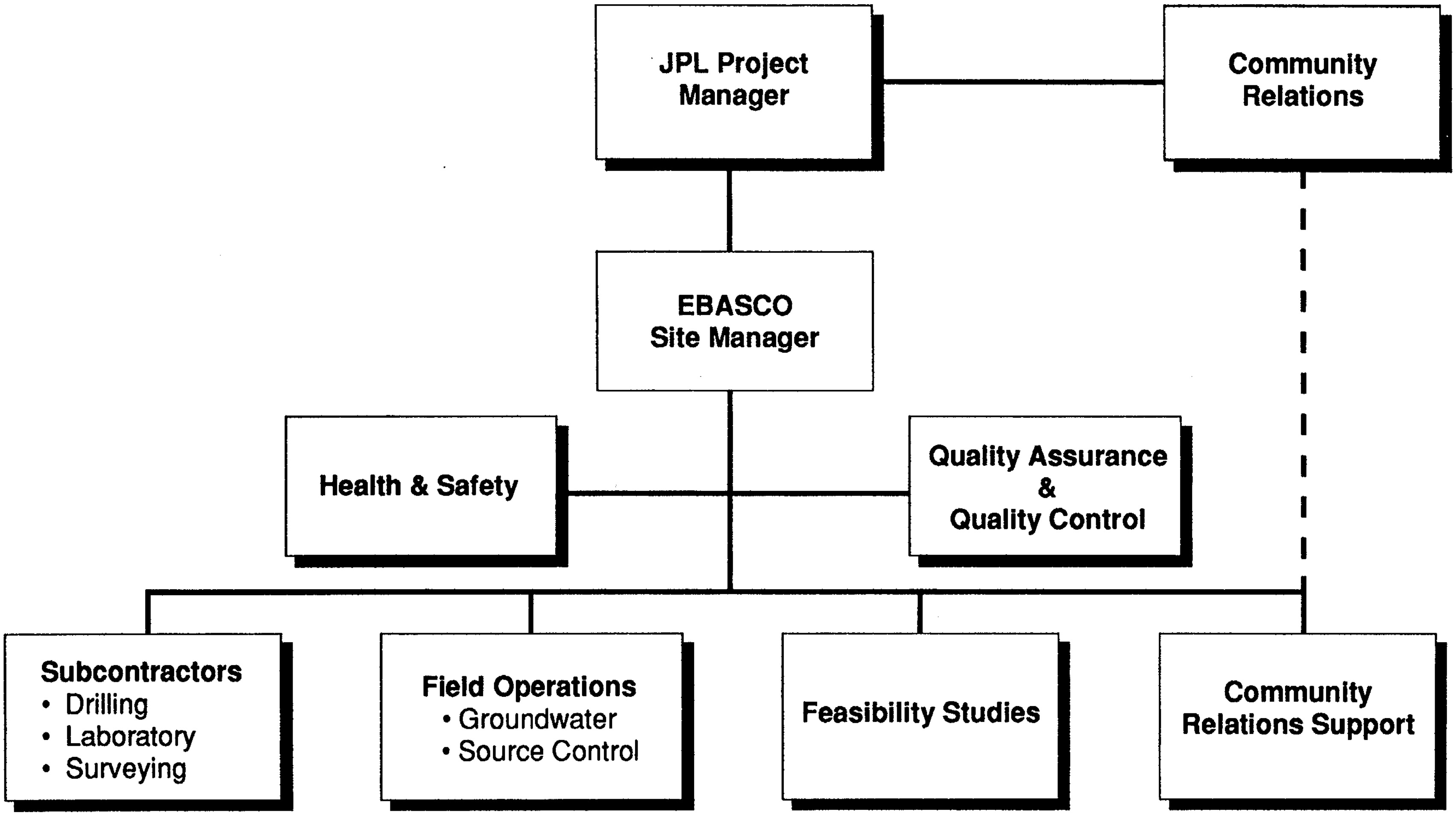
6.1 PROJECT ORGANIZATION AND APPROACH

The project activities will be organized as shown in Figure 6-1. The JPL Project Manager will direct all activities conducted during the proposed RI/FS. In that role, the JPL Project Manager will interface with both the lead regulatory agency, the Ebasco Project Director, the Ebasco Site Manager, and the JPL Community Relations Coordinator.

The JPL Community Relations Coordinator will lead the community relations effort on behalf of JPL. The Community Relations Coordinator will prepare fact sheets documenting project accomplishments and schedules of significant activities. The Community Relations Coordinator will also work with the JPL Project Manager to provide meeting support for public interactions. Ebasco will support the JPL Community Relations Coordinator with community relations programs and activities.

A representative from Ebasco will serve as Site Manager for the technical and administrative aspects of completing the proposed RI/FS. The Site Manager will receive assistance during this project from a number of people identified in Figure 6-1. In particular, a health and safety specialist will write the site specific health and safety plan and monitor the health and safety of all personnel conducting field studies. Another specialist will monitor the quality of all work conducted both in the field and in the laboratory. The field operations have been separated into two distinct areas of concern in this work plan and thus two individuals will monitor the groundwater and the source control portions of the RI.

Figure 6-1
JPL RI/FS PROJECT MANAGEMENT ORGANIZATION



The Feasibility Studies will be directed by Ebasco. The Site Manager will also manage the procurement and monitor the progress of all subcontractors used as part of the RI/FS.

The RI/FS activities will be separated into tasks as outlined in the text of this work plan. Should the need arise, the RI may be extended into additional phases depending on the results of the activities proposed here.

6.2 PROJECT QUALITY ASSURANCE AND DATA MANAGEMENT

The project's quality assurance and data management activities will be directed and monitored by Ebasco. Standard QA/QC procedures will be implemented by the subcontractors selected to perform drilling, sampling, and chemical analyses. All of the procedures used were developed to comply with both EPA and the State of California Department of Health Services Guidelines and include:

- o Strict adherence to EPA procedures for sample collection, storage, container and preservation techniques.

- o Chain of custody documentation.

During the course of sampling, Ebasco will collect replicate samples of groundwater and field blanks for laboratory analyses to assess data quality.

Chemical data validation will be performed to determine the usability of the laboratory data provided. The data review process will assess data quality with respect to both technical and contractual requirements. Close examination of analytical data will ensure that:

- o All QC requirements (e.g., instrument calibrations, blanks, spikes, recoveries, holding times) were performed and a valid analysis was performed.

- o Data are reliable for the intended use(s).

Data obtained during the site investigation will be evaluated as part of the ongoing site assessment as the investigation proceeds. Once all the data from the various field tasks are compiled, an evaluation report of the data will be prepared. This evaluation will ensure the data are sufficient in quality to meet the characterization objectives outlined. The following considerations will be included in the data evaluation:

- A historical review of the site including agency reports of incidences, maps, surface photos, notices of violations, and soil reports will be collected and analyzed for pertinent data.

- The location, thickness, and character of areas containing waste will be outlined.

- Site geology will be depicted on a geologic cross-section that will include subsurface data obtained from new monitoring wells. The cross-section will be referenced on a base map.

- Data and maps with groundwater flow directions will be prepared.

Upon completion of the Remedial Investigation, all raw laboratory data will be presented in the final report. Laboratory Quality Control summaries will also be included.

7.0 PROJECT SCHEDULE

An estimated schedule to accomplish the Remedial Investigation and Feasibility Study for JPL is shown in Table 7-1. This schedule is generic for each activity based on our past experience. As the schedule shows, some tasks must be completed before others can begin.

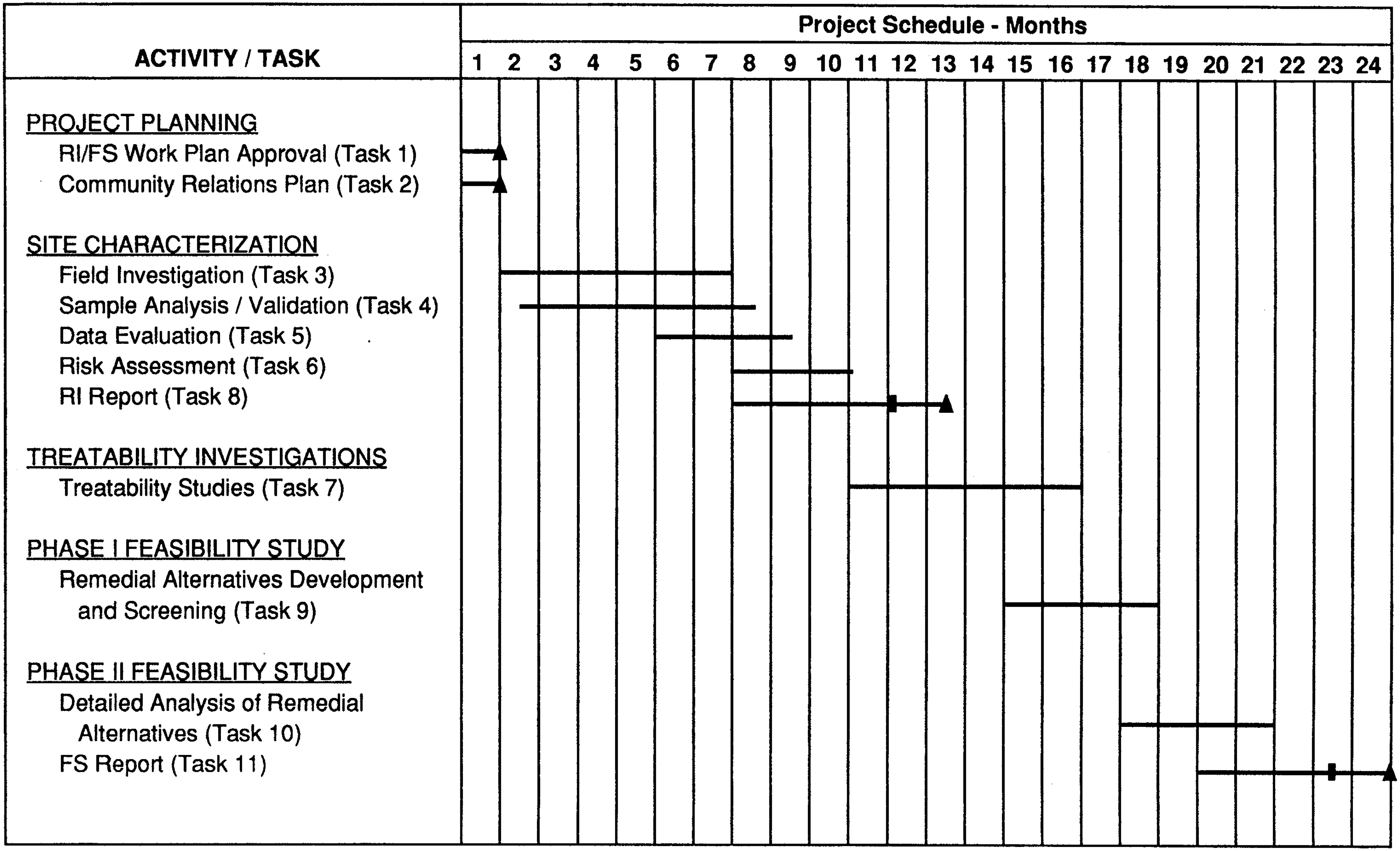
The following assumptions were made during the development of the schedule:

- o Field activities will not be affected by weather conditions and unplanned procurement/mobilization delays.
- o Report production and reviews will be conducted in a timely fashion.
- o Interpretations of site conditions based on analysis of data collected during the Remedial Investigation will not be significantly altered during potential later stages of data collection and analysis.
- o No delays are caused by unanticipated health and safety concerns.

Because JPL has not yet been listed on the NPL and the EPA is not yet technically the lead agency for this project, there is a degree of uncertainty associated with the schedule.

Table 7-1

Estimated Schedule for the Remedial Investigation / Feasibility Study Program



Legend: ▲ Final ▮ Draft

8.0 REFERENCES

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